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Indian Standard

CODE OF PRACTICE FOR ELECTRICAL WIRING INSTALLATIONS

(*Third Revision*)

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CODE OF PRACTICE FOR ELECTRICAL WIRING INSTALLATIONS

(Third Revision)

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(*Continued on page* 2)

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Indian Standard

CODE OF PRACTICE FOR ELECTRICAL WIRING INSTALLATIONS

(Third Revision)

0. FOREWORD

0.1 This Indian Standard was adopted by the Bureau of Indian Standards on 25 January 1989, after the draft finalized by the Low Voltage Switchgear and Controlgear Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The Indian Electricity Rules, together with the supplementary regulations of the state electricity departments and electricity undertakings, govern the electrical installation work in buildings in this country. Regulations for the electrical equipment in buildings as recommended by the Institution of Electrical Engineers, UK, have also often been followed in this work. Expanding use of electricity and increase in the number of electrical installations in buildings, necessitated the preparation of a code of practice to guide and govern installation of electrical wiring in buildings, with particular reference to safety and good engineering practice. This code was, therefore, first published in 1958 with the above objective.

0.3 Since the first version of this code covered electrical installations only in buildings which could be considered as non-industrial locations, where the system voltage generally did not exceed 650 volts, the need for having a similar code for industrial locations was also felt and many additional requirements had to be looked after. Therefore, in addition to the revision of this code, a separate code on the latter subject was published as IS : 2274-1963*.

0.4 Experience in implementation of these standards had proved that most of the 'industrial' installations required references to guidelines for system of voltages not exceeding 650 V in their design. Moreover, considerations such as layout of electrical installations, measurement, etc, for which separate Indian Standard specifications exist, require comprehensive reading, and it has been felt that a single Indian Standard to provide for all aspects of wiring would serve as a comprehensive reference guide on the subject.

0.5 In the second version of IS : 732 brought out in 1982 in 3 parts, this fact has been taken into account in that the information has been called from various Indian Standard specifications and other literature available and presented as a single comprehensive code. Efforts were made to identify gaps and the opportunity utilised to incorporate the latest trends in wiring practice. It is, however, indicated that this revision was purely a temporary measure to meet the immediate needs of the practising engineers and the ultimate aim was to bring out a comprehensive safety-oriented code on electrical installations in buildings based on the international work in this regard.

0.6 Soon after the publication of the second revision, work on the preparation of National Electrical Code (NEC) began under the purview of the National Electrical Code Sectional Committee, ETDC 56. This work, aimed as a compendium of all relevant information in IS Codes including IS : 732, concluded in 1985 when NEC was published. NEC besides drawing assistance from IS : 732, further elaborates the stipulations on wiring practice with reference to specific occupancies.

0.7 During the preparation of NEC it became evident that IS : 732 would require considerable updating in order to align with modified pattern of power consumption and advancing technology in installation design. There was also a strong need to align the code with the work being accomplished at the international level, namely, at the level of IEC/TC 64 'Electrical Installations of Buildings', which cover comprehensively the relevant issues. This revision of IS : 732 (third) is an attempt to improve the contents of the code to meet this need.

0.8 It is emphasized that the information contained in this code is oriented towards electrical safety. The accent is on protection from the various hazards arising from use of electricity and the rules relating to wiring practice are based on the international guidelines on such matters. It is in this respect that the present version of this standard differs from the earlier versions which were oriented towards design and constructional aspects. However, a series of appendices have been added to this Code dealing with specific guidelines on wiring practice as applicable to design, construction and execution of work. Whenever necessary, the provisions of this Code shall be read in conjunction with other Codes such as those on earthing, lightning protection, etc.

---

*Code of practice for electrical wiring installations (system voltage exceeding 650 volts).

0.9 In the preparation of this standard, considerable assistance has been derived from the following publications:

IEC Pub 364 (in several parts) Electrical Installations of Buildings. The International Electrotechnical Commission (IEC).

IEC Doc: 64 (Secretariat) 437 Electrical Installations of Buildings. Part 2 Definitions. International Electrotechnical Commission (IEC).

IEC Doc: (IEV 826) (Central Office) 1193 International Electrotechnional Vocabulary. Part 826 Electrical Installations of Buildings. The International Electrotechnical Commission (IEC).

IEC Doc: 64 (Secretariat) 430. Pub 364 Chapter 52 Selection and Erection of Wiring Systems. The International Electrotechnical Commission (IEC).

IEE Wiring Regulations 'Regulations for electrical installations' 15th Edition (1981) (as amended up to January 1985). The Institution of Electrical Engineers (UK).

0.10 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

---

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This code covers the essential requirements and precautions regarding wiring installations for ensuring satisfactory and reliable service and safety from all possible hazards from the use of electricity.

1.2 This code applies to the design, selection, erection and inspection and testing of wiring installations whether permanent or temporary, in and about buildings.

1.3 It relates generally to all wiring installations in non-industrial and industrial locations, whether the electric supply is derived from an external source or from a private generating plant.

1.4 Installations utilizing the following nominal voltage ranges are dealt with in this code:

a) voltages normally not exceeding 50 V ac or 120 V dc whether between conductors or to earth.

b) voltages normally exceeding extra-low voltage but not exceeding 1 000 V ac or 1 500 V dc between conductors or 600 V ac or 900 V dc between conductors and earth.

1.5 This code covers all general guidelines applicable to installations operating within the ranges given in **1.4**. Supplementary or additional provisions may be neccssary to be complied with in respect of specific occupancies depending on their nature. For the purposes of guidelines on individual occupancies reference may be National Electrical Code (SP : 30-1985).

1.6 This code is not applicable to the following:

a) Systems for distribution of energy to the public, or to power generation and transmission for such systems.

b) Wiring installations in special locations such as mines or other areas where potentially explosive atmosphere exists.

c) Lightning conductors, telecommunications and alarm systems.

d) Traction installations, motor vehicles, installations on board ships, aircraft or offshore installations.

1.7 This code also does not apply to matters concerning specifications of individual items of equipment and does not deal with requirements for the construction of prefabricated assemblies of electrical equipment.

SECTION 1 TERMINOLOGY

2. TERMINOLOGY

2.0 For the purposes of this standard, the following definitions shall apply.

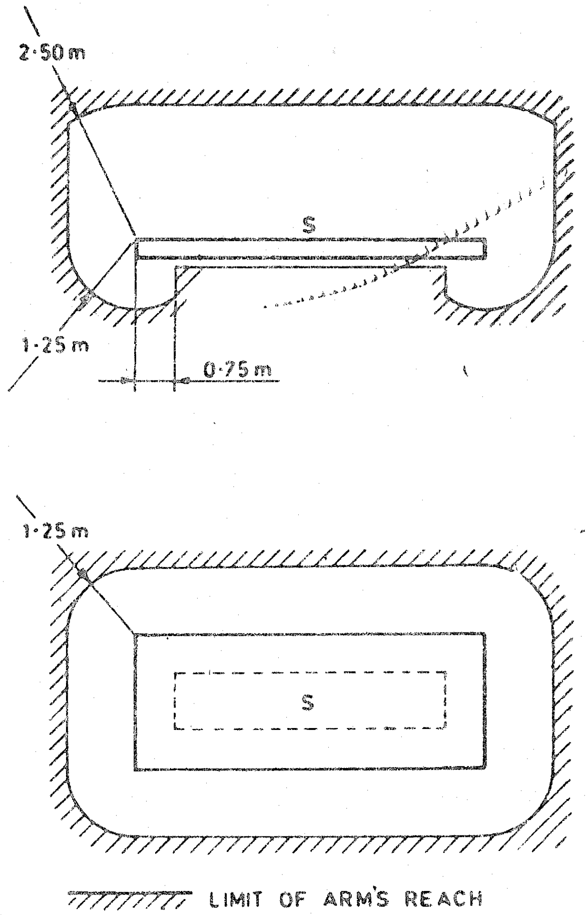
2.1 Accessory — A device, other than current-using equipment, associated with such equipment or with the wiring of an installation.

2.2 Ambient Temperature — The temperature of the air or other medium where the equipment is to be used.

2.3 Appliance — An item of current using equipment other than a luminaire or an independent motor.

2.4 Arm's Reach — A zone extending from any point on a surface where persons usually stand or move about, to the limits which a person can reach with the hand in any direction without assistance.

Note — This space is by convention, limited as shown in Fig. 1.



S = Surface expected to be occupied by person

Fig. 1 Arm's Reach

2.5 Barrier — A part providing a defined degree of protection against contact with live parts, from any usual direction of access.

2.6 Basic Insulation — Insulation applied to live parts to provide basic protection against electric shock.

Note — Basic insulation does not necessarily include insulation used exclusively for functional purposes.

2.7 Bonding Conductor — A protective conductor providing equipotential bonding.

2.8 Building Voids — Space within the structure or the components of a building accessible only at certain points.

Note 1 — Examples are: Space within partitions, suspended floors, ceilings and certain types of window frame, door frame and architraves.

Note 2 — Specially formed building voids are also known as ducts.

2.9 Buried Direct — A cable laid in the ground in intimate contact with the soil.

2.10 Bunched — Cables are said to be bunched when two or more are contained within a single conduit, duct, ducting, or trunking or, if not enclosed, are not separated from each other.

2.11 Cable Channel — An enclosure situated above or in the ground, open or ventilated or closed, and having dimensions which do not permit the access of persons but allow access to the conductors and/or cables throughout their length during and after installation.

Note — A cable channel may or may not form part of the building construction

2.12 Cable Bracket — A cable support consisting of single devices fixed to elements of building or plant construction.

2.13 Cable Coupler — A means enabling the connection, at will, of two flexible cables. It consists of a connector and a plug.

2.14 Cable Ducting — A manufactured enclosure of metal or insulating material, other than conduit or cable trunking, intended for the protection of cables which are drawn-in after erection of the ducting, but which is not specifically intended to form part of a building structure.

2.15 Cable Trunking — A factory made closed support and protection system into which conductors and/or cables are laid after removal of the cover.

2.16 Cable Tunnel — An enclosure (corridor) containing supporting structures for conductors and/or cables and joints and whose dimensions allow free access to persons throughout the entire length.

2.17 Cable Tray — A cable support consisting of a continuous base with raised edges and no covering. A cable tray is considered to be non-perforated where less than 30 percent of the material is removed from the base.

2.18 Cable Ladder — A cable support occupying less than 10 percent of the plan area and consisting of a series of supporting elements rigidly fixed to each other or to a main supporting member or members.

2.19 Cartridge Fuse Link — A device comprising a fuse element or several fuse elements connected in parallel enclosed in a cartridge usually filled with an arc-extinguishing medium and connected to terminations. The fuse link is the part of a fuse which requires replacing after the fuse has operated.

2.20 Circuit — An assembly of electrical equipment supplied from the same origin and protected against overcurrent by the same protective device(s). Certain types of circuit are categorised as follows:

a) *Category 1 Circuit* — A circuit (other than a fire alarm or emergency lighting circuit) operating at low voltage and supplied directly from a mains supply system.

b) *Category 2 Circuit* — With the exception of fire alarm and emergency lighting circuits, any circuit for telecommunication (for example, radio, telephone, sound distribution, intruder alarm, bell and call and data transmission circuits) which is supplied from a safety source.

c) *Category 3 Circuit* — A fire alarm circuit or an emergency lighting circuit.

2.21 Circuit Breaker — A mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions and also of making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions such as those of short circuit.

NOTE — A circuit breaker is usually intended to operate infrequently, although some types are suitable for frequent operation.

2.22 Class I Equipment — Equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in such a way that means are provided for the connection of exposed conductive parts to a protective conductor in the fixed wiring of installation in such a way that accessible conductive parts may not become live in the event of a failure of basic installation.

NOTE — For information on classification of equipment with regard to means provided for protection against electric shock, *see* IS : 9409-1980*.

2.23 Class II Equipment — Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double or reinforced insulation are provided, there being no provision for the connection of exposed metalwork of the equipment to a protective conductor, and no reliance upon precautions to be taken in the fixed wiring of the installation.

2.24 Conduit — A part of a closed wiring system a circular or non-circular cross section for conductors and/or cables in electrical installations, allowing them to be drawn in and/or replaced.

Conduits should be sufficiently closed-jointed so that the conductors can only be drawn in and not inserted laterally.

2.25 Confined Conductive Location — A location having surfaces which are mainly composed of extraneous condutive parts and which are of such dimensions that movement is restricted to such an extent that contact with surfaces is difficult to avoid (for example, in a boiler).

2.26 Connector — The part of a cable coupler or of an appliance coupler which is provided with female contact and is intended to be attached to the flexible cable connected to the supply.

2.27 Conventional Touch Voltage Limit — Maximum value of the touch voltage which is permitted to be maintained indefinitely in specified conditions of external influences.

2.28 Conventional Operating Current (of a Protective Device)— A specified value of the current which causes the protective device to operate within a specified time, designated conventional time.

NOTE — For fuses this current is called the 'conventional fusing current'. For circuit breakers this current is called the 'conventional operating current'.

The conventional operating current is greater than the rated current or current setting of the device and the conventional time varies according to the type and rated current of the protective device.

2.29 Current Carrying Capacity of a Conductor — The maximum current which can be carried by a conductor under specified conditions without its steady state temperature exceeding a specified value.

2.30 Current Using Equipment — Equipment which converts electrical energy into another form of energy, such as light, heat, or motive power.

2.31 Danger — Danger to health or danger to life or limb from shock, burn or injury from mechanical movement to persons (and livestock where present), or from fire attendent upon the use of electrical energy.

2.32 Design Current (of a Circuit) — The magnitude of the current intended to be carried by the circuit in normal service.

2.33 Direct Contact — Contact of persons or livestock with live parts which may result in electric shock.

2.34 Distribution Circuit (of Buildings)— A circuit supplying a distributing board.

2.35 Double Insulation — Insulation comprising both basic insulation and supplementary insulation.

2.36 Duct — A closed passage way formed underground or in a structure and intended to receive one or more cables which may be drawn in.

2.37 Ducting — *See* 2.14.

2.38 Earth — The conductive mass of the earth, whose electric potential at any point is conventionally taken as zero.

2.39 Earth Electrode — A conductor or group of conductors in intimate contact with and providing an electrical connection to earth.

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*Classification of electrical and electronic equipment with regard to protection against electric shock.

2.40 Earth Electrode Resistance — The resistance of an earth electrode to earth.

2.41 Earth Fault Loop Impedance — The impedance of the earth fault current loop (phase to earth loop) starting and ending at the point of earth fault.

2.42 Earth Leakage Current — A current which flows to earth, or to extraneous conductive parts, in a circuit which is electrically sound.

NOTE — This current may have a capacitive component including that resulting from the deliberate use of capacitors.

2.43 Earthing Resistance, Total — The resistance between the main earthing terminal and the earth.

2.44 Earthed Concentric Wiring — A wiring system in which one or more insulated conductors are completely surrounded throughout their length by a conductor, for example a sheath, which acts as a PEN conductor.

2.45 Earthing Conductor—A protective conductor connecting the main earth terminal (or equipotential bonding conductor of an installation when there is no earth bus) to an earth electrode or to other means of earthing.

2.46 Electric Shock — A dangerous pathophysiological effect resulting from the passing of an electric current through a human body or an animal.

2.47 Electrical Equipment (*abb:* **Equipment**) — Any item for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy, such as machines, transformers, apparatus, measuring instruments, protective devices, wiring materials, accessories, and appliances.

2.48 Electrical Installation (of a Building)— An assembly of associated electrical equipment to fulfil a specific purpose or purposes and having coordinated characteristics.

2.49 Electrically Independent Earth Electrodes — Earth electrodes located at such a distance from one another that the maximum current likely to flow through one of them does not significantly affect the potential of the other(s).

2.50 Electrode Boiler (or Electrode Water Heater) — Equipment for the electrical heating of water or electrolyte by the passage of an electric current between electrodes immersed in the water or electrolyte.

2.51 Emergency Switching — Rapid cutting off of electrical energy to remove any hazard to persons, livestock, or property which may occur unexpectedly.

2.52 Enclosure — A part providing protection of equipment againstc ertain external influences and, in any direction, protection against direct contact.

2.53 Equipment — *See* **2.47**.

2.54 Equipotential Bonding — Electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential.

NOTE — In a building installation equipotential bonding conductors shall interconnect the following conductive parts:

a) Protective conductor,
b) Earth continuity conductor, and
c) Risers of air-conditioning system and heating systems (if any).

2.55 Exposed Conductive Part — A conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault conditions.

2.56 External Influence — Any influence external to an electrical installation which affects the design and safe operation of that installation.

2.57 Extraneous Conductive Part — A conductive part not forming part of the electrical installation and liable to introduce a potential, generally the earth potential.

2.58 Factory Built Assembly (of LV Switchgear and Controlgear) — *See* IS : 862 (Part 1)-1977*.

2.59 Final Circuit — A circuit connected directly to current using equipment, or to a socket outlets or other outlet points for the connection of such equipment.

2.60 Fixed Equipment — Equipment fastened to a support or otherwise secured.

2.61 Functional Earthing — Connection to earth necessary for proper functioning of electrical equipment.

2.62 Fuse Element — A part of a fuse designed to melt when the fuse operates.

2.63 Fuse Link — A part of fuse, including the fuse element(s), which requires replacement by a new or renewable fuse link after the fuse has operated and before the fuse is put back into service.

2.64 Hand-Held Equipment — Portable equipment intended to be held in the hand during normal use, in which the motor, if any, forms an integral part of the equipment.

NOTE — A hand-held equipment is an item of equipment, the functioning of which requires constant manual support or guidance.

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*Specification for factory built assemblies of switchgear and controlgear for voltages upto and including 1 000 volt ac and 1 200 volt dc: Part 1 General requirements.

2.65 Indirect Contact — Contact of persons or livestock with exposed conductive parts made live by a fault and which may result in electric shock.

2.66 Installations — *See* 2.48.

2.67 Insulating Floor (or Wall) — A floor (or wall) such that, in the event of direct contact with a live part, a person standing on the floor (or touching the wall) cannot be traversed by a shock current flowing to the floor (or wall).

2.68 Insulation—Suitable non-conductive material enclosing surrounding, or supporting a conductor.

NOTE — *See* also the definitions for basic insulation, double insulation, reinforced insulation and supplementary insulation.

2.69 Isolation — Cutting off an electrical installation, a circuit, or an item of equipment from every source of electrical energy.

2.70 Live Part — A conductor or conductive part intended to be energised in normal use including a neutral conductor but, by convention, not a PEN conductor.

2.71 Luminaire — Equipment which distributes filters or transforms the light from one or more lamps, and which includes any parts necessary for supporting, fixing and protecting the lamps, but not the lamps themselves, and, where necessary, circuit auxiliaries together with the means for connecting them to the supply.

NOTE — For the purposes of this code a batten lampholder, or a lampholder suspended by flexible cord, is a luminaire.

2.72 Main Earthing Terminal — The terminal or bar which is the equipotential bonding conductor of protective conductors, and conductors for functional earthing, if any, to the means of earthing.

2.73 Mechanical Maintenance — The replacement, refurbishment or cleaning of lamps and non-electrical parts of equipment, plant and machinery.

2.74 Neutral Conductor (Symbol *N*) — A conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy.

2.75 Nominal Voltage — *See* 2.109.

2.76 Obstacle— A part preventing unintentional contact with live parts but not preventing deliberate contact.

2.77 Origin of an Electrical Installation — The point at which electrical energy is delivered to an installation.

NOTE — An electrical installation may have more than one origin.

2.78 Overcurrent — A current exceeding the rated value. For conductors the rated value is the current carrying capacity.

2.79 Overcurrent Detection — A method of establishing that the value of current in a circuit exceeds a predetermined value for a specified length of time.

2.80 Overload Current (of a Circuit) — An overcurrent occurring in a circuit in the absence of an electrical fault.

2.81 PEN Conductor — A conductor combining the functions of both protective conductor and neutral conductor.

2.82 Phase Conductor — A conductor of an ac system for the transmission of electrical energy, other than a neutral conductor.

NOTE — The term also means the equivalent conductor of a dc system unless otherwise specified in this code.

2.83 Plug — A device, provided with contact pins, which is intended to be attached to a flexible cable, and which can be engaged with a socket outlet or with a connector.

2.84 Point (in Wiring) — A termination of the fixed wiring intended for the connection of current using equipment.

2.85 Portable Equipment — Equipment which is moved while in operation or which can easily be moved from one place to another while connected to the supply.

2.86 Prospective Touch Voltage — The highest touch voltage liable to appear in the event of a fault of negligible impedance in the electrical installation.

2.87 Protective Conductor — A conductor used for some measures of protection against electric shock and intended for connecting together any of the following parts:

a) Exposed conductive parts,
b) Extraneous conductive parts,
c) The main earthing terminal, and
d) The earthed point of the source, or an artificial neutral.

2.88 Reinforced Insulation — Single insulation applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant standard.

NOTE — The term 'single insulation' does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

2.89 Residual Current — The algebraic sum of the instantaneous values of current flowing through all live conductors of a circuit at a point of the electrical installation.

2.90 Residual Current Device (RCD) — A mechanical switching device or association of devices intended to cause the opening of the contacts when the residual current attains a given value under specified conditions.

2.91 Residual Operating Current — Residual current which causes the residual current device to operate under specified conditions.

2.92 Resistance Area (for an Earth Electrode only) — The surface area of ground (around an earth electrode) on which a significant voltage gradient may exist.

2.93 Ring Final Circuit — A final circuit arranged in the form of a ring and connected to a single point of supply.

2.94 Shock Current—A current passing through the body of a person or an animal and having characteristics likely to cause dangerous pathophysiological effects.

2.95 Short-Circuit Current — An overcurrent resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions.

2.96 Simultaneously Accessible Parts — Conductors or conductive parts which can be touched simultaneously by a person or, where applicable by livestock.

NOTE — In the context of protection against direct contacts a live part may be accessible with:

a) another live part, or
b) an exposed conductive part, or
c) an extraneous conductive part, or
d) a protective conductor.

The following may constitute simultaneously accessible parts in the context of protection against indirect contacts:

a) Exposed conductive parts,
b) Extraneous conductive parts, and
c) Protective conductors.

It should be noted that the word touched signifies any contact with any part of the body (hand, foot, head, etc).

2.97 Socket Outlet — A device, provided with female contacts, which is intended to be installed with the fixed wiring, and intended to receive a plug.

NOTE — A luminaire track system is not regarded as a socket outlet system.

2.98 Space Factor — The ratio (expressed as a percentage) of the sum of the overall cross-sectional areas of cables (including insulation and sheath) to the internal cross-sectional area of the conduit or other cable enclosure in which they are installed. The effective overall cross-sectional area of a non-circular cable is taken as that of a circle of diameter equal to the major axis of the cable.

2.99 Spur — A branch cable connected to a ring or radial final circuit.

2.100 Standby Supply System — A system intended to maintain supply to the installation or part thereof, in case of interruption of the normal supply, for reasons other than safety of persons.

NOTE — Standby supplies are necessary, for example, to avoid interruption of continuous industrial processes or data processing.

2.101 Stationary Equipment — Either fixed equipment or equipment not provided with a carrying handle and having such a mass that it cannot easily be moved.

2.102 Supplementary Insulation — Independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation.

2.103 Switch — A mechanical switching device capable of making, carrying and breaking current under normal circuit conditions, which may include specified operating overload conditions, and also of carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit.

NOTE — A switch may also be capable of making, but not breaking, short-circuit currents.

2.104 Switch, Linked — A switch the contacts of which are so arranged as to make or break all poles simultaneously or in a definite sequence.

2.105 Switchboard — An assembly of switchgear with or without instruments, but the term does not apply to a group of local switches in a final circuit.

NOTE — The term 'switchboard' includes a distribution board.

2.106 Switchgear — An assembly of main and auxiliary switching apparatus for operation, regulation, protection or other control of electrical installations.

NOTE — For more comprehensive definitions of the terms in **2.103** to **2.106** (*see* IS : 1885 (Part 17)-1987*.

2.107 System — An electrical system consisting of a single source of electrical energy and an installation.

NOTE — The types of systems depending upon the relationship to the source and of the exposed conductive parts of the installation to earth are defined in IS : 3043-1987†.

2.108 Touch Voltage — The potential difference between a grounded metallic structure and a point on the earths surface separated by a distance equal to the normal maximum horizontal reach approximately 1 metre.

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*Electrotechnical vocabulary: Part 17 Switchgear and controlgear (*first revision*).

†Code of practice for earthing.

2.109 Voltage, Nominal (of an Installation)— Voltage by which an installation or part of an installation is designated.

SECTION 2 ASSESSMENT OF GENERAL CHARACTERISTICS OF INSTALLATIONS

3. ASSESSMENT OF CHARACTERISTICS

3.0 An assessment shall be made of the following characteristics of the installation in accordance with the clauses indicated:

a) The purpose for which the installation is intended to be used, its general structure, and its supplies (**3.1**);

b) The external influences to which it is to be exposed (**3.2**);

c) The compatibility of its equipment (**3.3**); and

d) Its maintainability (**3.4**).

These characteristics shall be taken into account in the choice of methods of protection for safety (*see* Section 3) and the selection and erection of equipment (*see* Section 4).

3.1 Purposes, Supplies and Structure

3.1.1 *Maximum Demand* — The maximum demand of the installation, expressed as a current value, shall be assessed.

3.1.2 *Diversity* — In determining the maximum demand of an installation or parts thereof, diversity may be taken into account.

3.1.3 *Arrangement of Live Conductors and Type of Earthing*

3.1.3.1 *General* — The characteristics mentioned in **3.1.3.2** and **3.1.3.3** shall be ascertained in order to determine which methods of protection for safety, will be appropriate.

3.1.3.2 *Number and types of live conductors* — The number and types of live conductors (for example single-phase two-wire ac, three-phase four-wire ac) shall be assessed, both for the source of energy and for the circuits to be used within the installation. Where the source of energy is provided by a supply undertaking, that undertakings shall be consulted, if necessary.

3.1.3.3 *Types of earthing arrangement* — The type of earthing arrangement or arrangements to be used for the installation shall be determined.

3.1.4 *Nature of Supply*

3.1.4.1 *General* — The following characteristics of the supply or supplies shall be ascertained for an external supply and shall be determined for a private source:

a) Nominal voltage(s);

b) Nature of current and frequency;

c) Prospective short-circuit current at the origin of the installation;

d) Type and rating of the overcurrent protective device acting at the origin of the installation;

e) Suitability for the requirements of the installation, including the maximum demand; and

f) The earth loop impedance of that part of the system external to the installation.

Note — As regards item (f), it may only be possible to ascertain an expected maximum value.

3.1.4.2 *Supplies for safety services and standby purposes* — Where a supply for safety services or standby purposes is specified, the characteristics of the sources of any such supply shall be assessed. Such supplies shall have adequate capacity, reliability and rating and appropriate changeover time for the operation specified.

Where the normal source of energy is to be provided by a supply undertaking, the supply undertaking shall be consulted regarding switching arrangements for safety and standby supplies, especially where the various sources are intended to operate in parallel.

Note — For further requirements for supplies for safety services *see* **3.4**.

3.1.5 *Installation Circuit Arrangements*

3.1.5.1 Every installation shall be divided into circuits as necessary to:

a) avoid danger and minimise inconvenience in the event of a fault, and

b) facilitate safe operation, inspection, testing, and maintenance.

3.1.5.2 Separate circuits shall be provided for parts of the installation which need to be separately controlled, in such a way that these circuits are not affected by failure of other circuits.

3.1.5.3 The number of final circuits required, and the number of points supplied by any final circuit, shall be such as to comply with the requirements for overcurrent protection, for isolation and switching, and as regards current-carrying capacities of conductors.

3.1.5.4 Where an installation comprises more than one final circuit, each final circuit shall be connected to a separate way in a distribution board. The wiring of each final circuit shall be electrically separate from that of every other final circuit, so as to prevent indirect energisation of a final circuit intended to be isolated.

3.2 Compatibility

3.2.1 An assessment shall be made of any characteristics of equipment likely to have harmful effects upon other electrical equipment or other services, or likely to impair the supply. The characteristics include, for example:

a) transient overvoltages;

b) rapidly fluctuating loads;

c) starting currents;

d) harmonic currents (such as with fluorescent lighting loads and thyristor drives);

e) mutual inductance;

f) dc feedback;

g) high frequency oscillations;

h) earth leakage currents; and

j) any need for additional connections to earth (for example, for equipment needing a connection with earth independent of the main means of earthing of the installation, for the avoidance of interference with its operation).

NOTE — For an external source of energy it is essential that the supply undertaking be consulted regarding any equipment of the installation having a characteristic likely to have a significant influence on the supply, for example, having heavy starting currents.

3.3 Maintainability

3.3.1 An assessment shall be made of the frequency and quality of maintenance that the installation can reasonably be expected to receive during its intended life. This assessment shall, wherever practicable, include consultation with the person or body who will be responsible for the operation and maintenance of the installation. Having regard to the frequency and quality of maintenance expected, the requirements of this Code shall be applied so that:

a) any periodic inspection, testing, maintenance and repairs likely to be necessary during the intended life can be readily and sefely carried out;

b) the protective measures for safety remain effective during the intended life; and

c) the reliability of equipment is appropriate to the intended life.

3.4 Supplies for Safety Services

NOTE — The need for safety services and their nature are frequently regulated by statutory authorities whose requirements have to be observed.

3.4.1 *General* — The following sources for safety services are recognized:

a) storage batteries,

b) primary cells,

c) generator sets independent of the normal supply, and

d) a separate feeder effectively independent of the normal feeder.

NOTE — The use of separate independent feeders should be based on an assessment that the two supplies are unlikely to fail concurrently.

3.4.2 *Classification* — A safety service is either:

a non-automatic supply, the starting of which is initiated by an operator, or

an automatic supply, the starting of which is independent of an operator.

An automatic supply is classified according to changeover time:

a) *no-break* — an automatic supply which can ensure a continuous supply within specified conditions during the period of transition, for example, as regards variations in voltage and frequency;

b) *very short break*: an automatic supply available within 0·15 second;

c) *short break*: an automatic supply available within 0·5 second;

d) *medium break*: an automatic supply available within 15 seconds; and

e) *long break*: an automatic supply available in more than 15 seconds.

4. EXTERNAL INFLUENCES

4.1 Identification of External Influences on the Electrical Installation

4.1.1 The characteristics of the following external influences shall be assessed:

1) *Environments*
   a) Ambient temperature,
   b) Atmospheric humidity,
   c) Altitude,
   d) Presence of water,
   e) Presence of foreign solid bodies,
   f) Presence of corrosive or polluting substances,
   g) Mechanical stresses,
   h) Presence of flora and/or mould growth,
   j) Presence of fauna,
   k) Electromagnetic, electrostatic or ionizing influences,
   m) Solar radiation,
   n) Seismic effects,
   p) Lightning, and
   q) Wind.
2) *Utilization*
   a) Capability of persons,
   b) Electrical resistance of human body,

- c) Contact of persons with earth potential,
- d) Conditions of evacuation in an emergency, and
- e) Nature of processed or stored material.

3) *Construction of Buildings*

- a) Constructional materials, and
- b) Building design.

4.1.2 Table 1 suggests the classification and codification of external influences which require assessment in the design and erection of electrical installation.

NOTE 1 — Each condition of external influence is designated by a code comprising a group of two capital letters and a number as follows:

The first letter relates to the general category of external influence :

A = environment
B = utilization
C = construction of buildings

The second letter relates to the nature of the external influence:

A...
B...
C...

The number relates to the class within each external influence :

1...
2...
3...

For example, the code AC 2 signifies:

A = environment
AC = environment altitude
AC2 = environment altitude > 2 000 m.

The code given here is not intended to be used for marking equipment.

NOTE 2 — The characteristics defined for electrical installations are those accepted by the IEC and as applicable for electrical installations in buildings. Influences on outdoor installations are separately defined in the respective parts of the Code.

For the time being, the characteristics of influences (col 2, Table 1) are given in descriptive language only. Codification for the same (*see* Note 1 above), as recommended by IEC are given in col 4 for information. It is hoped that in due course the users of the Code would be familiar with the codification in terms of which the requirements would be stated in future editions.

4.2 Compatibility — An assessment shall be made of any characteristics of equipment likely to have harmful effects upon other electrical equipment or other services or likely to impair the supply. Those characteristics include, for example:

- a) transient overvoltages,
- b) rapidly fluctuating loads,
- c) starting currents,
- d) harmonic currents,
- e) dc feedback,
- f) high-frequency oscillations, and
- g) earth leakage currents.

4.3 Maintainability — An assessment shall be made of the frequency and quality of maintenance the installation can reasonably be expected to receive, during its intended life. Where an authority is to be responsible for the operation of the installation, that authority shall be consulted. Those characteristics are to be taken into account in applying the requirements of this code so that, having regard to the frequency and quality of maintenance expected:

- a) any periodic inspection and testing and maintenance and repairs likely to be necessary during the intended life can be readily and safely carried out,
- b) the effectiveness of the protective measures for safety during the intended life is ensured, and
- c) the reliability of equipment for proper functioning of the installation is appropriate to the intended life.

TABLE 1 ASSESSMENT OF GENERAL CHARARCTERISTICS OF BUILDINGS

(*Clause* 4.1.2)

Class Designation (1)	Characteristics (2)	Application and Examples (3)	Code (4)
	Environment		
1) Ambient temperature	The ambient temperature to be considered for the equipment is the temperature at the place where the equipment is to be installed resulting from the influence of all other equipment in the same location, when operating, not taking into account the thermal contribution of the equipment to be installed.		
	Lower and upper limits of ranges of ambient temperature:		
	−60°C +5°C		AA1
	−40°C +5°C		AA2
	−25°C +5°C		AA3
	−5°C +40°C		AA4
	+5°C +40°C		AA5
	+5°C +60°C		AA6
	The average temperature over a 24 hour period must not exceed 5°C below the upper limits.		
	Combination of two ranges to define some environments may be necessary. Installations subject to temperatures outside the ranges require special consideration.		
2) Atmospheric humidity	under consideration		
3) Altitude	$< 2\ 000$ m		AC1
	$> 2\ 000$ m		AC2
4) Presence of water			
Negligible	Probability of presence of water is negligible	Locations in which the walls do not generally show traces of water but may do so for short periods, for example, in the form of vapour which good ventilation dries rapidly	AD1
Free-falling drops	Possibility of vertically falling drops	Locations in which water vapour occasionally condenses as drops or where steam may occasionally be present	AD2
Sprays	Possibility of water falling as spray at an angle up to 60°C from the vertical	Locations in which sprayed water forms a continuous film on floors and/or walls	AD3
Splashes	Possibility of splashes from any direction	Locations where equipment may be subjected to splashed water, this applies, for example, to certain external lighting fittings, construction site equipment, etc.	AD4
Jets	Possibility of jets of water from any direction	Locations where hosewater is used regularly (yards, car-washing bays)	AD5
Waves	Possibility of water waves	Seashore locations such as piers, beaches, quays, etc.	AD6
Immersion	Possibility of intermittent partial or total covering by water	Locations which may be flooded and/or where water may be at least 150 mm above the highest point of equipment, the lowest part of equipment being not more than 1 m below the water surface	AD7
Submersion	Possibility of permanent and total covering by water	Locations such as swimming pools where electrical equipment is permanently and totally covered with water under a pressure greater than 0·1 bar	AD8

(*Continued*)

TABLE 1 ASSESSMENT OF GENERAL CHARACTERISTICS OF BUILDINGS — *Contd*

CLASS DESIGNATION (1)	CHARACTERISTICS (2)	APPLICATIONS AND EXAMPLES (3)	CODE (4)
5) Presence of foreign solid bodies:			
Negligible	The quantity of nature of dust or foreign solid bodies is not significant		AE1
Small Objects	Presence of foreign solid bodies where the smallest dimension is not less than 2·5 mm	Tools and small objects are examples of foreign solid bodies of which the smallest dimension is at least 2·5 mm	AE2
Very small objects	Presence of foreign solid bodies where the smallest dimension is not less than 1 mm NOTE — In conditions AEI and AE3, dust may be present but is not significant to operation of the electrical equipment	Wires are examples of foreign solid bodies of which the smallest dimension is not less than 1 mm.	AE3
Dust	Presence of dust is significant quantity		AE4
6) Presence of corrosive or polluting subtances:			
Negligible	The quantity or nature of corrosive or polluting substances is not significant		AF1
Atmospheric	The presence of corrosive or polluting substance of atmospheric origin is significant	Installations situated by the sea or industrial zones producing serious atmospheric pollution, such as chemical works and cement works; this type of pollution arises especially in the production of abrasive, insulating or conductive dusts	AF2
Intermittent or accidental	Intermittent or accidental subjection to corrosive or polluting chemical substances being used or produced	Locations where some chemical products are handled in small quantities and where these products may come only accidentally into contact with electrical equipment; such conditions are found in factory, laboratories, other laboratories, or in locations where hydro-carbons are used (boiler-rooms, garages, etc).	AF3
Continuous	Continuously subject to corrosive or polluting chemical substances in substantial quantity	For example, chemical works	AF4
7) Mechanical Stresses:			
a) Impact			
Low severity		Household and similar conditions	AG1
Medium severity		Usual industrial conditions	AG2
High severity	NOTE — Provisional classification. Quantitative expression of impact severities is under consideration	Severe industrial conditions	AG3
b) Vibration			
Low severity		Household and similar conditions where the effects of vibration are generally negligible	AH1
Medium severity		Usual industrial conditions	AH2
High severity	NOTE — Provisional classification. Quantitative expression of vibration severities is under consideration	Industrial installations subject to severe conditions	AH3

(*Continued*)

TABLE 1 ASSESSMENT OF GENERAL CHARACTERISTICS OF BUILDINGS — *Contd*

CLASS DESIGNATION (1)	CHARACTERISTICS (2)	APPLICATIONS AND EXAMPLES (3)	CODE (4)
c) Other mechanical stresses		Under consideration	AJ
8) Presence of fungus and/or mould growth:			
No hazard	No hazard of fungus and/or mould growth		AK1
Hazard	hazard of fungus and/or mould growth	The hazard depends on local conditions and the nature of fungus. Distinction should be made between harmful growth of vegetation or conditions for promotion of mould growth	AK2
9) Presence of vermin:			
No hazard	No hazard		AL1
Hazard	Hazard from fauna (insects, birds, small animals)	The hazard depends on the nature of the vermin. Distinction should be made between: — presence of insects in harmful quantity or of an aggressive nature — presence of small animals or birds in harmful quantity or of an aggressive nature	AL2
10) Electromagnetic, electrostatic or ionizing influences:			
Negligible	No harmful effects from stray currents, electromagnetic radiation, electrostatic fields, ionizing radiation or induction		AM1
Stray currents	Harmful hazards of stray currents		AM2
Electromagnetics	Harmful presence of electromagnetic radiation		AM3
Ionization	Harmful presence of ionizing radiation		AM4
Electrostatics	Harmful presence of electrostatic fields		AM5
Induction	Harmful presence of induced currents		AM6
11) Solar radiation			
Negligible			AN1
Significant	Solar radiation of harmful intensity and/or duration		AN2
12) Seismic effects			
Negligible	Up to 30 Gal (1 Gal = 1 cm/s^2)		AP1
Low severity	Over 30 up to and including 300 Gal		AP2
Medium severity	Over 300 up to and including 600 Gal		AP3
High severity	Greater than 600 Gal	Vibration which may cause the destruction of the building is outside the classification Frequency is not taken into account in the classification; however, if the seismic wave resonates with the building, seismic effects must be specially considered. In general, the frequency of seismic acceleration is between 0 and 10 Hz	AP4

(*Continued*

TABLE 1 ASSESSMENT OF GENERAL CHARACTERISTICS OF BUILDINGS — *Contd*

CLASS DESIGNATION (1)	CHARACTERISTICS (2)	APPLICATIONS AND EXAMPLES (3)	CODE (4)
13) Lightning			
Negligible			AQ1
Indirect exposure	Hazard from supply arrangements	Installations supplied by overhead lines	AQ2
Direct exposure	Hazard from exposure of equipment	Parts of installations located outside buildings. The risks AQ2 and AQ3 relate to regions with a particularly high level of thunderstorm activity	AQ3
14) Wind (Under consideration)			
	Utilization		
1) Capability of persons			
Ordinary	Uninstructed persons		BA1
Children	Children in locations intended for their occupation NOTE — This class does not necessarily apply to family dwellings	Nurseries	BA2
Handicapped	Persons not in command of all their physical and intellectual abilities (sick persons, old persons)	Hospitals	BA3
Instructed	Persons adequately advised or supervised by skilled persons to enable them to avoid dangers which electricity may create (operating and maintenance staff)	Electrical operating areas	BA4
Skilled	Persons with technical knowledge or sufficient experience to enable them to avoid dangers which electricity may create (engineers and technicians)	Closed electrical operating areas	BA5
2) Electrical resistance of the human body			
Classification (Under consideration)			BB
3) Contact of Persons with earth potential			
None	Persons in non-conducting situations	Non-conducting locations	BC1
Low	Persons do not in usual conditions make contact with extraneous conductive parts or stand on conducting surfaces		BC2
Frequent	Persons are frequently in touch with extraneous conductive parts or stand on conducting surfaces	Locations with extraneous conductive parts, either numerous or of large area	BC3
Continuous	Persons are in permanent contact with metallic surroundings and for whom the possibility of interrupting contact is limited	Metallic surroundings such as boilers and tanks	BC4
4) Conditions of evacuation in an emergency			
	Low density occupation, easy conditions of evacuation	Buildings of normal or low height used for habitation	BD1
	Low density occupation, difficult conditions of evacuation	High-rise buildings	BD2
	High density occupation, easy conditions of evacuation	Locations open to the public (theatres, cinemas)	BD3
	High density occupation, difficult conditions of evacuation	High-rise buildings open to the public (hotels, hospitals, etc)	BD4

(*Continued*)

TABLE 1 ASSESSMENT OF GENERAL CHARACTERISTICS OF BUILDINGS — *Contd*

CLASS DESIGNATION (1)	CHARACTERISTICS (2)	APPLICATIONS AND EXAMPLES (3)	CODE (4)
5) Nature of processed or stored materials			
No significant risks	—	—	BE1
Fire risks	Manufacture, processing or storage of flammable materials including presence of dust	Barns, wood-working shops, paper factories	BE2
Explosion risk	Processing or storage of explosive or low flashpoint materials including presence of explosive dusts	Oil refineries, hydrocarbon stores	BE3
Contamination risks	Presence of unprotected foodstuffs, pharmaceutics, and similar products without protection	Foodstuff industries, kitchens NOTE — Certain precautions may be necessary, in the event of fault, to prevent processed materials being contaminated by electrical equipment, for example, by broken lamps	BE4
	Constructions of Building		
1) Constructional materials			
Non-combustible	—		CA1
Combustible	Buildings mainly constructed of combustible materials	Wooden buildings	CA2
2) Building design			
Negligible risk	—	—	CB1
Propagation of fire	Buildings of which the shape and dimensions facilitate the spread of fire (for example, chimney effects)	High-rise buildings, forced ventilation systems	CB2
Movement	Risks due to structural movement (for example, displacement between a building and the ground, or settlement of ground or building foundations)	Buildings of considerable length or erected on unstable ground Contraction or expansion joints	CB3
Flexible or unstable	Structures which are weak or subjects to movement (for example, oscillation)	Tents, air-support structures, false ceilings, removable partitions Flexible wiring, installations needing support	CB4

SECTION 3 PROTECTION FOR SAFETY

5. REQUIREMENTS FOR PROTECTION FOR SAFETY

5.0 Fundamental Requirements for Safety — The requirements for protection for safety of persons, livestock and property involve protection against electric shock, thermal effects, overcurrent, overvoltage and undervoltage and a measure of isolation and switching of electric circuits. The protective measures may be applicable to the entire installation or a part or an item of equipment. The requirements stated below in this Section are based on the following basic principles.

5.0.1 *Protection Against Direct Contact* — Persons and livestock shall be protected against dangers that may arise from contact with live parts of the installation.

This protection can be achieved by one of the following methods:

a) Preventing a current from passing through the body of any person or any livestock; and

b) Limiting the current which can pass through a body to a value lower than the shock current.

5.0.2 *Protection Against Indirect Contact* — Persons and livestock shall be protected against dangers that may arise from contact with exposed conductive parts.

This protection can be achieved by one of the following methods:

a) Preventing a fault current from passing through the body of any person or any livestock;

b) Limiting the fault current which can pass through a body to a value lower than the shock current; and

c) Automatic disconnection of the supply on the occurrence of a fault likely to cause a current to flow through a body in contact with exposed conductive parts, where the value of that current is equal to or greater than the shock current.

5.0.3 *Protection Against Thermal Effects in Normal Service* — The electrical installation shall be so arranged that there is no risk of melting besides ignition of flammable materials due to high temperature or electric arc. Also during normal operation of the electrical equipment, there shall be no risk of persons or livestock suffering burns.

5.0.4 *Protection Against Overcurrent* — Persons or livestock shall be protected against injury and property shall be protected against damage due to excessive temparatures or electromechanical stresses caused by any overcurrents likely to arise in live conductors.

This protection can be achieved by one of the following methods:

a) Automatic disconnection on the occurrence of an overcurrent before this overcurrent attains a dangerous value taking into account its duration; and

b) Limiting the maximum overcurrent to a safe value and duration.

5.0.4.1 *Overcurrent protection devices* — Where necessary to prevent danger, every installation and every circuit thereof shall be protected against overcurrent by devices which:

a) will operate automatically at values of current which are suitably related to the safe current ratings of the circuit;

b) are of adequate breaking capacity and, where appropriate, making capacity; and

c) are suitably located and are constructed so as to prevent danger from overheating, arcing or the scattering of hot particles when they come into operation and to permit ready restoration of the supply without danger.

NOTE — Where the supply undertaking provides switchgear or fusegear at the origin of the installation it may not be necessary to duplicate the means of overcurrent protection for that part of the installation between its origin and the main distribution point of the installation where the next step for overcurrent protection is provided. In domestic installations the protection and isolating functions are combined in the same device.

5.0.5 *Protection Against Fault Currents* — Conductors, other than live conductors, and any other parts intended to carry a fault current shall be capable of carrying that current without assuming excessive temperature, until the protective gear operates.

NOTE 1 — Particular attention should be given to earth fault currents.

NOTE 2 — For live conductors, compliance with 5 assures their protection against any fault currents, including overcurrents.

5.0.5.1 *Precautions against earth leakage and earth fault currents* — Where metalwork of electrical equipment, other than current-carrying conductors, may become charged with electricity in such a manner as to cause danger if the insulation of a conductor should become defective or if a fault should occur in any equipment:

a) the metalwork shall be earthed in such a manner as will cause discharge of electrical energy without danger, or

b) other equally effective precautions shall be taken to prevent danger.

Every circuit shall be arranged so as to prevent the persistence of dangerous earth leakage currents.

Where metalwork is earthed, the circuits concerned shall be protected against the persistence of dangerous earth fault currents by:

a) the overcurrent protective devices required by **5.0.4.1**, or

b) a residual current operated device or equally effective device.

The method described in (b) above shall be used whenever the prospective earth fault current is insufficient to cause prompt operation of the overcurrent protective devices.

Where necessary to prevent danger and where metalwork of electrical equipment is earthed for compliance with (a) above and is accessible simultaneously with substantial exposed metal parts of other services, the latter parts shall be effectively connected to the main earthing terminal of the installation.

5.0.6 *Protection Against Overvoltage* — Persons or livestock shall be protected against injury and property shall be protected against any harmful effects of a fault between live parts of circuits supplied at different voltages.

Persons or livestock shall be protected against injury and property shall be protected against damage from any excessive voltages likely to arise due to other causes (for example, atmospheric phenomena or switching voltages).

SECTION 3A PROTECTION AGAINST ELECTRIC SHOCK

5.1 Requirements for Protection Against Electric Shock

5.1.1 *Protection Against Both Direct and Indirect Contact*

5.1.1.1 *General* — One of the following basic protective measures for protection against both direct contact and indirect contact shall be used:

a) Protection by safety extra low voltage,

b) Protection by functional extra low voltage, and

c) Protection by limitation of discharge of energy.

5.1.1.2 *Protection by safety extra low voltage* — Protection against electric shock is provided when all the following requirements are fulfilled:

a) The nominal voltage of the circuit concerned does not exceed extra low voltage.

b) The supply is from one of the safety sources listed in (1) below.

c) The conditions of (2) below are fulfilled.

NOTE — Lower voltage limits may be required for certain conditions of external influences.

1) *Safety sources* — The safety source shall be one of the following:

   i) A class II safety isolating transformer, the secondary-winding being isolated from earth.

   ii) A source of current providing a degree of safety equivalent to that of the safety isolating transformer specified in (a) above (for example, a motor generator with windings providing equivalent isolation).

   iii) An electrochemical source (for example, a battery) or another source independent of a higher voltage circuit (for example, a engine-driven generator).

   iv) Electronic devices where measures have been taken so that even in the case of an internal fault the voltage at the outgoing terminals cannot exceed extra low voltage.

2) *Arrangement of Circuits*

   i) Live parts of safety extra low voltage circuits shall not be connected to earth or to live parts or protective conductor forming part of other circuits.

   ii` Exposed conductive parts of safety extra low voltage circuits shall not intentionally be connected to any of the following:

      1) Earth,

      2) Protective conductors or exposed conductive parts of another system, or

      3) Extraneous conductive parts, except that where electrical equipment is inherently required to be connected to extraneous conductive parts it shall be verified that those parts cannot attain a voltage exceeding the limit of the safety extra low voltage circuit. If the exposed conductive parts of safety extra low voltage circuits are liable to come into contact fortuitously with exposed conductive parts of other circuits, the protection no longer depends solely on the measure for protection by safety extra low voltage and shall be in accordance with the requirements for the measures applicable to the latter exposed conductive parts.

   iii) Live parts of safety extra low voltage equipment other than cables shall be electrically separate from those of higher voltage circuits. The electrical separation between live parts of safety extra low voltage circuits and higher voltage circuits shall be not less than that between the input and output windings of safety isolating transformers.

   iv) Safety extra low voltage circuit conductors shall preferably be physically separated from those of any other circuit. Where this requirement is impracticable, one of the following arrangements is required:

      1) Safety extra low voltage circuit conductors shall be insulated in accordance with the requirements of this code for the highest voltage present.

      2) Safety extra low voltage circuit cables shall be non-metallic sheathed cables.

      3) Conductors of circuits at different voltages shall be separated from those at safety extra low voltage by an earthed metallic screen or an earthed metallic sheath.

      4) Circuits at different voltages may be contained in a multicore cable or other grouping of conductors but the conductors of safety extra low

voltage circuits shall be insulated, individually or collectively, for the highest voltage present.

NOTE — In arrangements (2) and (3) basic insulation of any conductor need be sufficient only for the voltage of the circuit of which it is a part.

v) Plugs and socket outlets of safety extra low voltage circuits shall comply with all of the following requirements:

1) The plugs shall not be capable of entering socket outlets of other voltage systems in use in the same premises.

2) The socket outlets shall exclude plugs of other voltage systems in use in the same premises.

3) The socket outlets shall not have a protective conductor connection.

vi) Mobile safety sources shall be selected or erected in accordance with **5.1.3.2**.

vii) If the nominal voltage exceeds 25 V ac rms 50 Hz, or 60 V ripple-free dc, protection against direct contact shall be provided by one or more of the following:

1) Barriers or enclosures affording at least the degree of protection IP 2X.

2) Insulation capable of withstanding a test voltage 500 V dc for one minute.

If the nominal voltage does not exceed 25 V ac rms 50 Hz, or 60 V ripple-free dc, protection against direct contact is not required by this code except as specified below:

Application of Protective Measure — Safety extra-low voltage

a) *Where the use of safety extra-low voltage (SELV) is relied upon for protection against direct contact, that is, where live parts are not insulated or provided with barriers and enclosures in accordance with* **5.1.1.2**(2) (vii), *the nominal voltage shall not in any event exceed 25 V rms ac or 60 V ripple-free dc. These voltage limits are applicable only to conditions where simultaneously accessible parts may be touched by a person having a body resistance assumed as conventionally normal, and shall be appropriately reduced in eonditions where reduced or very low body resistance is to be expected.*

b) *Where SELV is used for protection against indirect contact only, and where the live parts of the SELV circuit are insulated or provided with barriers and enclosures in accordance with* **5.1.1.2**(2)(vii), *the nominal voltage shall not in any event exceed 50 V rms ac or 120 V ripple-free dc. These voltage limits are applicable only to conditions where simultaneously accessible parts may be touched by a person having a conventionally normal body resistance, and shall be appropriately reduced in conditions where reduced or very low body resistance is to be expected.*

NOTE — Conventionally normal body resistance relates to a contact involving one hand and both feet, the skin being dry or moist with perspiration (but not wet). Reduced body resistance may be expected in situations where the hands and/or feet are likely to be wet or where the shock current path may not be through the extremities, and very low body resistance (of the order of one quarter of the conventionally normal body resistance) is to be expected in locations where a person is immersed in water or working in confined conductive locations.

5.1.1.3 *Functional extra low voltage systems*

a) If for functional reasons extra low voltage is used but not all the requirements of **5.1.1.2** regarding safety extra low voltage are fulfilled, the appropriate measures described in (b) to (e) below shall be taken in order to ensure protection against electric shock. Systems employing these measures are termed 'functional extra low voltage systems'.

NOTE — Such conditions may, for example, be encountered in extra low voltage circuits when one point of the extra low voltage circuit is connected to earth or if the circuit contains components (such as transformers, relays, remote-control switches, contactors) insufficiently insulated with respect to circuits at higher voltages.

b) If the extra low voltage system complies with the requirements of **5.1.1.2** for safety extra low voltage except that live or exposed conductive parts are connected to earth or to the protective conductors of the systems [*see* **5.1.1.2**(b)(i) and (ii)] protection against direct contact shall be provided by one or more of the following:

i) Enclosures giving protection at least equivalent to IP 2X.

ii) Insulation capable for resisting a test voltage of 500 V rms for one minute.

Such a system is connected to afford protection against indirect contact.

This requirement does not exclude the installation or the use without supplementary protection of equipment conforming to the relevant standard, providing an equivalent degree of safety.

c) If the extra low voltage system does not generally comply with the requirements of **5.1.1** for safety extra low voltage, protection against direct contact shall be provided by one or more of the following:

i) Barriers or enclosures according to **5.1.2.2**.

ii) Insulation corresponding to the minimum test voltage required for the primary circuit.

In addition, protection against indirect contact shall be provided in accordance with (d) below.

The extra low voltage circuit may be used to supply factory built equipment whose insulation does not comply with the minimum test voltage required for the primary circuit provided that the accessible insulation of that equipment is reinforced during erection to withstand a test voltage of 1 500 V rms for one minute.

d) If the primary circuit of the functional extra low voltage source is protected by automatic disconnection, exposed conductive parts of the equipment in the functional extra low voltage circuit shall be connected to the protective conductor of the primary circuit.

NOTE — This does not exclude the possibility of connecting a conductor of the functional extra low voltage circuit to the protective conductor of the primary circuit.

If the primary circuit of the functional extra low voltage source is protected by electrical separation, the exposed conductive parts of equipment in the functional extra low voltage circuit shall be connected to the non-earthed protective conductor of the primary circuit.

NOTE — This latter requirement does not contravene 5.1.3.5(c), the combination of the electrically separated circuit and the extra low voltage circuit being regarded as one electrically separated circuit.

e) The socket outlet of functional extra low voltage systems shall not admit plugs intended for use with other systems in use in the same premises.

Application of Protective Measure — Functional extra-low voltage

Where, for functional reasons, extra-low voltage is used but:

i) *One point of the extra-low voltage circuit is required to be earthed, or*

ii) *Live parts or exposed conductive parts of the extra-low voltage circuit are connected to the protective conductors of other systems (whether those protective conductors are earthed or not); or*

iii) *The insulation between the extra-low voltage circuits and other circuits is not equivalent to that provided by a safety source.*

The system shall be treated as a functional extra-low voltage system and **5.1.1.3** *apply.*

5.1.1.4 *Protection by limitation of discharge of energy* — For equipment complying with the appropriate standard, protection against electric shock is afforded when the equipment incorporates means of limiting the current which can pass through the body of a person or livestock to a value lower than the shock current. Circuits relying on this protective measure shall be separated from other circuits in a manner similar to that specified in 5.1.1.2(2)(iii) and (iv) for safety extra low voltage circuits.

Application of protective measure—Limitation of discharge of energy

This measure shall be applied only to individual items of current-using equipment complying with an appropriate Indian Standard, where the equipment incorporates means of limiting to a safe value the current that can flow from the equipment through the body of a person or livestock. The application of this measure may be extended to a part of an installation derived from such items of equipment, where the relevant Indian Standard concerned provides specifically for this, for example, to electric fences supplied from electric fence controllers.

5.1.2 *Protection Against Direct Contact*

5.1.2.0 *General* — One or more of the following basic protective measures for protection against direct contact shall be used:

a) Protection by insulation of live parts,

b) Protection by barriers or enclosures,

c) Protection by obstacles, and

d) Protection by placing out of reach.

5.1.2.1 *Protection by insulation of live parts* — Live parts shall be completely covered with insulation which can only be removed by destruction and which is capable of durably withstanding the mechanical, electrical, thermal and chemical stresses to which it may be subjected in service.

NOTE 1 — Where insulation is applied during the erection of the installation, the quality of the insulation should be confirmed by tests similar to those which ensure the quality of the insulation of similar factory built equipment.

NOTE 2 — General purpose, paints, varnishes, lacquers and similar products without additional insulation do not provide adequate insulation for protection against direct contact.

Application of protective measure — Insulation of live parts

This measure relates to basic insulation, and is intended to prevent contact with live parts. It is generally applicable for protection against direct contact, in conjunction with a measure for protection against indirect contact.

5.1.2.2 *Protection by barriers or enclosures*

a) Live parts shall be inside enclosures or behind barriers providing at least the degree of protection IP 2X except that, where an opening larger than that admitted for IP 2X is necessary to allow the replacement of parts or to avoid interference with the proper functioning of electrical equipment both of the following requirements apply:

   i) Suitable precautions shall be taken to prevent persons or livestock from unintentionally touching live parts, and

   ii) It shall be established as far as practicable, that persons will be aware that live parts can be touched through the opening and should not be touched.

b) Horizontal top surfaces of barriers or enclosures which are readily accessible shall provide a degree of protection of at least IP 4X.

c) Barriers and enclosures shall be firmly secured in place and have sufficient stability and durability to maintain the required degrees of protection and appropriate separation from live parts in the known conditions of normal service.

d) Where it is necessary to remove barriers or to open enclosures or to remove parts of enclosures, one or more of the following requirements shall be satisfied:

   i) The removal or opening shall be possible only by use of a key or tool,

   ii) The removal or opening shall be possible only after disconnection of the supply to live parts against which the barriers or enclosures afford protection, restoration of the supply being possible only after replacement or reclosure of the barriers or enclosures, and

   iii) An intermediate barrier shall be provided to prevent contact with live parts, such barrier affording a degree of protection of at least IP 2X and removable only by the use of a tool.

This requirement does not apply to ceiling roses or to ceiling switches operated by a cord.

Application of Protective Measure — Barriers or enclosures

a) *This measure is intended to prevent or deter any contact with live parts It is generally applicable for protection against direct contact in conjunction with a measure for protection against indirect contact.*

b) *The exception in* **5.1.2.2**(a) *allowing for openings larger than IP 2X in barriers or enclosures shall be applied only to items of equipment or accessories complying with an Indian Standard where compliance with the generality of* **5.1.2.2**(a) *is impracticable by reason of the function of those items, for example, to lampholders. Wherever that exception is used, the opening shall be as small as is consistent with the requirements for proper functioning and for replacement of parts.*

5.1.2.3 *Protection by obstacles*

a) Obstacles shall prevent, as appropriate, the following:

   i) Unintentional bodily approach to live parts, or

   ii) Unintentional contact with live parts when operating equipment live in normal use.

b) Obstacles shall be so secured as to prevent unintentional removal but may be removable without using a key or tool.

Application of Protective Measure — Obstacles

This measure is intended to prevent unintentional contact with live parts, but not intentional contact by deliberate circumvention af the obstacles. It shall be used only for protection against direct contact in areas accessible only to skilled persons, or instructed persons under direct supervision.

5.1.2.4 *Protection by placing out of reach*

a) Bare or PVC covered overhead lines for distribution between buildings and structures shall be installed in accordance with good practice.

b) Bare live parts shall not be within arm's reach.

c) Where bare live parts other than overhead lines are out of arm's reach but nevertheless may be accessible, they shall not be within 2·5 m of any of the following:

   i) Exposed conductive parts,

   ii) Extraneous conductive parts, and

   iii) Bare live parts of other circuits.

d) If a normally occupied position is restricted in the horizontal plane by an obstacle (for example, handrail mesh screen) affording a degree of protection less than IP 2X, arm's reach shall extend from that obstacle. In the overhead direction, arm's reach is 2·5 m from the surface *S* not taking into account any intermediate obstacle providing a degree of protection less than IP 2X (*see* Fig. 1).

   NOTE — The values of arm's reach refer to bare hands without any assistance, for example, from tools or a ladder.

e) In places where bulky or long conducting objects are normally handled, the distances required by (b) to (d) shall be increased accordingly.

Application of Protective Measure — Placing out of reach

This measure is intended only to prevent unintentional contact with live parts and shall be applied only for protection against direct contact. The application of the provisions of 5.1.2.4(b) *to* (d) *shall be limited to locations accessible only to skilled persons, or instructed persons under direct supervision.*

5.1.3 *Protection Against Indirect Contact*

5.1.3.0 *General* — One or more of the following basic protective measures for protection against indirect contact shall be used:

a) Earthed equipotential bonding and automatic disconnection of supply,

b) Use of Class II equipment or equivalent insulation,

c) Non-conducting location,

d) Earth free local equipotential bonding, and

e) Electrical separation.

5.1.3.1 *Protection by earthed equipotential bonding and automatic disconnection of supply*

a) General

  i) In each installation main equipotential bonding conductors complying with IS : 3043-1987* shall connect extraneous conductive parts including the following to the main earthing terminal for that insulation:

    1) Main water pipes,
    2) Main gas pipes,
    3) Other service pipes and ducting,
    4) Risers of central heating and air-conditioning systems, and
    5) Exposed metallic parts of the building structure.

NOTE 1 — This bonding is intended to create a zone in which any voltages between exposed conductive parts and extraneous conductive parts are minimised.

NOTE 2 — Compliance with (a) (i) will normally satisfy the relevant requirements of the protective multiple earthing.

NOTE 3 — Additional equipotential bonding may be required [*see* **5.1.3.1**(a)(v)].

  ii) The characteristics of the protective devices for automatic disconnection, the earthing arrangements for the installation and the relevant impedances of the circuits concerned shall be coordinated so that during an earth fault the voltages between simultaneously accessible exposed and extraneous conductive parts occurring anywhere in the installation shall be of such magnitude and duration as not to cause danger.

NOTE 1 — For information on types of earthing arrangements, *see* IS : 3043-1987*.

NOTE 2 — For the conditions of connection of exposed conductive parts *see* **5.1.3.1**(b) to (d) and as appropriate to the earthing arrangement concerned.

  iii) The provisions of (ii) above are considered to be satisfied if the automatic disconnection provided for occurs within the duration not permitting the touch voltage to exceed the safe value.

  iv) Where protection is afforded by an overcurrent protective device, and the nominal voltage to earth (U_0) is 240 V rms ac, the earth fault loop impedance (Z_s), for compliance with (iii) above, shall not exceed safe values.

  v) Where compliance with the disconnection times of (iii) above is afforded by a residual current device in an installation, the product of the rated residual operating current in amperes and the earth fault loop impedance in ohms shall not exceed the values given in IS : 3043-1987* for different types of system earthing.

  vi) Within the zone formed by the main equipotential bonding, local supplementary bonding connections shall be made to metal parts, to maintain the equipotential zone, where those parts:

    1) are extraneous conductive parts,
    2) are simultaneously accessible with exposed conductive parts or other extraneous conductive parts, and
    3) are not electrically connected to the main equipotential bonding by permanent and reliable metal-to-metal joints of negligible impedance.

NOTE — Where local equipotential bonding is provided in accordance with (vi) above, metalwork which may be required to be bonded includes baths and exposed metal pipes, sinks, taps, tanks and radiators and, where practicable, accessible structural metalwork.

b) Installations which are part of a TN system:

  i) All exposed conductive parts of the installation shall be connected by protective conductors to the main earthing terminal of the installation and that terminal shall be connected to the earthed point of the supply source in accordance with IS : 3043-1987*.

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*Code of practice for earthing (*first revision*).

*Code of practice for earthing.

- ii) The protective devices shall be of one or more of the following type:
    - 1) Overcurrent protective devices, and
    - 2) Residual current devices.

    Provided that where the neutral and the protective functions are combined in one conductor (PEN conductor) a residual current device shall not be used.

c) Installations which are part of a TT system:

- i) Where protection is afforded by overcurrent protective devices or residual current devices, exposed conductive parts shall be connected by protective conductors individually, in groups or collectively to an earth electrode or electrodes.
- ii) The protective devices shall be of one or more of the following types:
    - 1) Residual current devices, and
    - 2) Overcurrent protective devices.

d) Installations which are part of an IT system:

- i) No live conductor of the installation shall be directly connected to earth.

    NOTE — To reduce overvoltage or to damp voltage oscillations, it may be necessary to provide earthing through impedances or artificial neutral points and the characteristics of these should be appropriate to the requirements of the installation.

- ii) Exposed conductive parts shall be earthed either individually, in groups or collectively. Simultaneously accessible exposed conductive parts and associated extraneous conductive parts shall be connected only to an earth electrode common to those parts.
- iii) The protective devices shall be residual current devices.
- iv) An insulation monitoring device shall be provided to indicate the occurrence of first fault from a live part to exposed conductive parts or to earth. The device shall automatically disconnect the supply, or initiate an audible and/or visual signal.

    NOTE — First fault should be eliminated as quickly as practicable.

- v) After the occurrence of first fault, conditions for disconnection of supply, as specified for TN and TT systems, shall apply.

Application of protective measure — Automatic disconnection of supply

a) *This measure is generally applicable, and is intended to prevent the occurrence of voltage of such magnitude and duration between simultaneously accessible conductive parts that danger could arise. It includes all methods involving the earthing of exposed conductive parts. The limiting values of earth fault loop impedance specified in* **5.1.3.1** (a)(iv) *shall be applied where the conditions are such that conventionally normal body resistance applies. In conditions where reduced or very low body resistance is to be expected, either the earth fault loop impedance values shall be appropriately reduced or another protective measure shall be used.*

NOTE — Conventionally normal body resistance relates to a contact involving one hand and both feet, the skin being dry or moist with perspiration (but not wet). Reduced body resistance may be expected in situations where the hands and/or feet are likely to be wet or where the shock current path may not be through the extremities, and very low body resistance (of the order of one quarter of the conventionally normal body resistance) is to be expected in locations where a person is immersed in a water or working in confined conductive locations.

b) *The limiting values of earth fault loop impedance specified in* **5.1.3.1**(a)(iv) *are aqplicable only where the exposed conductive parts of the equipment concerned and any extraneous conductive parts are situated within the zone created by the main equipotential bonding* [*see* **5.1.3.1**(a)(i)].

Where a circuit originating in that zone is specifically intended to supply equipment to be used outside the zone, and that equipment may be touched by a person in contact directly with the general mass of earth, the following requirements apply:

- i) *For solidly grounded system it shall be sufficient to check whether the provisions of* **5.1.3.1** *are complied with in general;*
- ii) *It shall be verified whether the main overcurrent protection device affords the degree of protection envisaged by* **5.1.3.1**(a) (iv);
- iii) *Where the overcurrent protective device did not afford the degree of protection in* **5.1.3.1**(a) (iv) *and where the earthing is inadequate, a separate residual current device shall be installed, affording a protection in compliance with* **5.1.3.1**(a)(iv); *and*
- iv) *The automatic disconnecting device shall be so installed that proper discrimination between the circuits being protected is available.*

c) *Where the measure is used in a household or similar installation forming part of a TT system or where the earthing is not effective, every socket outlet circuit shall be protected by a residual current device having a rated residual operating current not exceeding 30 mA.*

d) *Automatic disconnection using residual current devices shall not be applied to circuits incorporating a PEN conductor. The measure is otherwise generally applicable, provided that the device is selected to have a residual operating current* *ensuring compliance with* **5.1.3.1** (a)(ii) *and* (v). *The use of such devices is preferred where the value of earth fault loop impedance prevents the use of overcurrent devices to obtain compliance with the disconnection times specified in* **5.1.3.1**(a)(iii).

Note — If a residual current device affording protection against indirect contact has a rated residual current equal to or less than 30 mA and an operating time of 40 ms or less at a residual current of 250 mA, it may also be used to reduce the risk associated with direct contact in case of failure of other protective measures. Such a device cannot be used as a sole means of protection against direct contact and does not obviate the need to apply one of the protective measure specified in **5.1.2.0**.

e) *Automatic disconnection using fault voltage operated protective devices is recognised for use in TT and IT systems and is suitabte where the impedance of the earth fault loop prevents compliance with* **5.1.2.2**(b) *and* (c) *by the use of overcurrent protective devices.*

5.1.3.2 *Protection by use of Class II equipment or by equivalent insulation*

a) Protection shall be provided by one or more of the following:

   i) Electrical equipment of the following types, type tested and marked to the relevant standards:

      1) Electrical equipment having double or reinforced insulation (Class II equipment).

      2) Factory built assemblies of electrical equipment having total insulation.

   ii) Supplementary insulation applied to electrical equipment having basic insulation only, as a process in the erection of an electrical installation, providing a degree of safety equivalent to that of electrical equipment according to (i)(1) above and complying with (b) to (j) below.

   iii) Reinforced insulation applied to uninsulated live parts, as a process in the erection of an electrical installation, providing a degree of safety equivalent to electrical equipment according to (i)(1) above and complying with (b) to (j), such insulation being recognized only where constructional features prevent the application of double insulation.

b) The installation of equipment described in item (a)(i) above (for example the fixing and connection of conductors) shall be effected in such a way as not to impair the protection afforded in compliance with the equipment specification, Class II equipment shall be so installed that basic insulation is not the only protection between live parts of the installation and exposed metalwork of that equipment.

c) The electrical equipment being ready for operation, all conductive parts separated from live parts by basic insulation only shall be contained in an insulating enclosures affording at least the degree of protection IP 2X.

d) The insulating enclosure shall be capable of resisting the mechanical, electrical and thermal stresses to which it is likely to be subjected.

Note — Coatings of paint, varnish and similar products are generally considered not to comply with (d).

e) If the insulating enclosure has not previously been tested, a suitable test shall be carried out (*see* Section 5).

f) The insulating enclosure shall not be pierced by conductive parts, other than circuit conductors, likely to transmit a potential. The insulating enclosure shall not contain any screws of insulating material, the replacement of which by metallic screws could impair the insulation provided by the enclosure.

Note—Where the insulating enclosure must be pierced by mechanical joints or connections (for example, for operating handles of built-in equipment, and for fixing screws) these should be arranged in such a way that protection against indirect contact is not impaired.

g) Where lids or doors in the insulating enclosure can be opened without the use of a tool or key, all conductive parts which are accessible if the lid or door is open shall be behind an insulating barrier which prevent persons from coming into contact with those parts; this insulating barrier shall provide a degree of protection of at least IP 2X and be removable only by use of a tool.

h) Conductive parts enclosed in the insulating enclosure shall not be connected to a protective conductor. However, provision may be made for connecting protective conductors which necessarily run through the enclosure in order to serve other items of electrical equipment whose supply circuit also runs through the enclosure. Inside that enclosure, any such conductors and their terminals or joints shall be insulated as though they were live parts and their terminals shall be appropriately marked.

j) The enclosure provided for this measure shall not adversely affect the operation of the equipment protected.

Application of protective measure — Class II equipment or equivalent insulation

a) *This measure is intended to prevent the appearance of a dangerous voltage on the exposed metalwork* *of electrical equipment through a fault in the basic insulation. It is generally applicable to items of equipment, either by the selection of equipment complying with an appropriate Indian Standard where that standard provides for the use of Class II construction or total insulation, or by the application of suitable supplementary insulation during erection.*

b) *Where a circuit supplies items of Class II equipment, a means of connection to the protective conductor of the circuit shall nevertheless be provided at every point for the supply of current-using equipment likely to be changed by the user, and at terminations for accessories similarly likely to be changed by the user. This requirement need not be observed where (c) below applies.*

NOTE — Exposed metalwork of Class II equipment should preferably be mounted so that it is not in electrical contact with any part of the installation connected to a protective conductor. Such a contact may impair the Class II protection provided by the equipment specification.

c) *Where this measure is to be used as a sole means of protection against indirect contact (that is, where a whole installation or circuit is intended to consist entirely of Class II equipment or the equivalent), it shall be verified that the installation or circuit concerned will be under effective supervision in normal use so that no change is made that would impair the effectiveness of the Class II or equivalent insulation. The measure shall not therefore be so applied to any circuit which includes socket outlets or where a user may change items of equipment without authorisation. Cables having a non-metallic sheath or a non-metallic enclosure shall not be described as being of Class II construction. However, the use of such cables installed in accordance with relevant standard is considered to afford satisfactory protection against direct and indirect contact.*

5.1.3.3 *Protection by non-conducting location*

a) Exposed conductive parts shall be arranged so that under ordinary circumstances a person will not come into simultaneous contact with:

   i) two exposed conductive parts, or

   ii) an exposed conductive part and any extraneous conductive part,

   if these parts are liable to be at different potentials through failure of the basic insulation of live parts.

b) In a non-conducting location there shall be no protective conductors, and any socket outlets shall not incorporate an earthing contact.

c) The resistance of insulating floors and walls at every point of measurement under the conditions specified in **12.3** shall be not less than:

   i) 50 kΩ where the supply voltage does not exceed 500 V, or

   ii) 100 kΩ where the supply voltage exceeds 500 V but does not exceed 1 000 V.

   If at any point the resistance is less than the specified value, the floors and walls are extraneous conductive parts for the purposes of protection against shock.

   NOTE — Steps may need to be taken so that humidity will not effect the resistance of floors and walls to such an extent that they do not comply with **5.1.3.3**(c).

d) The arrangements made shall be permanent. They shall also afford protection where the use of mobile or portable equipment is envisaged.

   NOTE — Attention is drawn to the risk that where electrical installations are not under effective supervision, further conductive parts may be introduced at a later date (for example, mobile or portable Class I equipment or metallic water pipes), which may invalidate compliance with (d).

e) Precautions shall be taken so that a potential on extraneous conductive parts in the location cannot be transmitted outside that location.

Requirement of **5.1.3.3**(a) is fulfilled if the location has an insulating floor and walls and one or more of the following arrangements applies:

1) Relative spacing of exposed conductive parts and of extraneous conductive parts as well as spacing of exposed conductive parts: This spacing is sufficient if the distance between two parts is not less than 2 m; this distance may be reduced while out of the zone of arm's reach.

2) Interposition of effective obstacles between exposed conductive parts and extraneous conductive parts: Such obstacles are sufficiently effective if they extend the distances to be surmounted to the values stated in (1) above. They shall not be connected to earth or to exposed conductive parts; as far as possible they shall be of insulating materials.

3) Insulation or insulating arrangement of extraneous conductive parts: The insulation shall be of adequate electrical and mechanical strength.

Application of Protective Measure — Non-conductive location

This measure is intended to prevent simultaneous contact with parts which may be at different potentials through failure of the basic insulation of live parts. It is not recognised in these clauses for general use, but may be applied in special situations under effective supervision, where specified by a suitably qualified electrical engineer.

5.1.3.4 *Protection by earth free local equipotential bonding*

a) Equipotential bonding conductors shall connect together all simultaneously accessible exposed conductive parts and extraneous conductive parts.

b) The local equipotential bonding conductors shall not be in electrical contact with earth directly, or through exposed conductive parts or through extraneous conductive parts.

   NOTE — Where (b) cannot be observed, requirements for protection by automatic disconnection of supply are applicable [*see* 5.1.3.1 (a) to (d)].

c) Precautions shall be taken so that persons entering the equipotential location cannot be exposed to dangerous potential difference, in particular, where a conductive floor insulated from earth is connected to the earth free equipotential bonding conductors.

Application of Protective Measure—Earth free local equipotential bonding

This measure is intended to prevent the appearance of a dangerous voltage between simultaneously accessible parts in the event of failure of the basic insulation. It shall be applied only in special situations which are earth free and under effective supervision and where specified by a suitably qualified electrical engineer.

5.1.3.5 *Protection by electrical separation* —The voltage of the electrically separated circuit shall not exceed 500 V:

a) Protection by electrical separation shall be afforded by compliance with (b) and (c) below and with (d) below for a supply to one item of equipment, or (e) below for a supply to more than one item of equipment.

b) The source of supply to the circuit shall comply with the following requirements:

   i) It shall be either:

      1) a safety isolating transformer, the secondary winding being isolated from earth; or

      2) a source of current providing a degree of safety equivalent to that of the safety isolating transformer referred to above (for example, a motor generator with windings providing equivalent isolation).

   ii) Mobile sources of supply fed from a fixed installation shall be selected or installed in accordance with 5.1.3.2(a) to (j), or

   iii) Equipment used as a fixed source of supply, shall be either:

      1) selected and installed in accordance with 5.1.3.2(a) to (j), or

      2) such that the output is separated from the input and from the enclosure by an isolation satisfying the conditions of 5.1.3.2(a) to (j). If such a source supplies several items of equipment, exposed metalwork of that equipment shall not be connected to the metallic enclosure of the source.

c) The separated circuit shall comply with the following requirements:

   i) Live parts of the separated circuit shall not be connected at any point to another circuit or to earth and to avoid the risk of a fault to earth, particular attention shall be given to the insulation of such parts from earth, especially for flexible cables and cords.

   ii) Flexible cables and cords shall be visible throughout every part of their length liable to mechanical damage.

   iii) A separate wiring system shall preferably be used for the separated circuit. Alternatively, multicore cables without metallic sheath, or insulated conductors in insulating conduit shall be used, their rated voltage being not less than the highest voltage likely to occur, and each circuit shall be protected against overcurrent.

   iv) Live parts of the separate circuit shall be electrically separated from other circuits. Arrangements shall ensure electrical separation not less than that between the input and output of a safety isolating transformer.

      NOTE — In particular, electrical separation is necessary between the live parts of electrical equipment such as relays, contactors, auxiliary switches and any part of another circuit.

d) For a circuit supplying a single item of equipment, no exposed metalwork of the separated circuit shall be connected intentionally either to the protective conductor or to exposed conductive parts of other circuits.

e) If precautions are taken to protect the separated circuit from damage and insulation failure, a source of supply complying with 5.1.3.5(b)(i) to (iii) may supply more than one item of equipment provided that all the following requirements are fulfilled:

   i) The exposed metalwork of the separated circuit shall be connected together by insulated and non-earthed equipotential bonding conductors. Such conductors shall not be connected to the protective conductors or exposed conductive parts of other circuits or to any extraneous conductive parts.

ii) All socket outlets shall be provided with protective contacts which shall be connected to equipotential bonding conductors provided in accordance with (i) above.

iii) All flexible cables of equipment other than Class II equipment shall embody a protective conductor for use as an equipotential bonding conductor.

iv) It shall be verified that, if two faults to exposed metalwork occur and these are fed by conductors of different polarity, an associated protective device will meet the requirements of **5.1.3.1**(a)(ii).

Application of Protective Measure—Electrical separation

This measure is intended, in the individual circuit, to prevent shock currents through contact with exposed conductive parts which might be energised by a fault in the basic insulation of that circuit. It may be applied to the supply of any individual item of equipment by means of a transformer the secondary of which is not earthed, or a source of equivalent safety. Its use to supply several items of equipment from a single separated source is recognised in these clauses only for special situations under effective supervision, where specified by a suitably qualified electrical engineer.

5.1.4 *Special Provisions and Exemptions*

5.1.4.1 For areas to which only skilled persons, or instructed persons under direct supervision, have access it is sufficient to provide against unintentional contact with live parts by use of obstacles in accordance with **5.1.2.3**, or by placing of live parts out of reach in accordance with **5.1.2.4**, subject also to **5.1.4.2** to **5.1.4.4**.

5.1.4.2 The dimensions of passage-ways and working platforms for open type switchboards and other equipment having exposed live parts shall comply with relevant standards, as appropriate to the nominal voltage of the live parts.

5.1.4.3 For areas which are accessible only to skilled persons by the use of a safety ward lock key or tools, the measures of protection against electric shock specified in this section may be totally dispensed with, where this is permitted by the appropriate authority.

5.1.4.4 Areas reserved for skilled or instructed persons shall be clearly and visibly indicated by suitable warning signs.

5.1.4.5 It is permissible to dispense with measures of protection against indirect contact in the following instances:

a) Overhead line insulator wall brackets and metal parts connected to them if such parts are not situated within arm's reach.

b) Steel reinforced concrete poles in which the steel reinforcement is not accessible.

c) Exposed conductive parts, which owing to their reduced dimensions or their disposition cannot be gripped or cannot be contacted by a major surface of the human body, provided that connection of these parts to a protective conductor cannot readily be made or cannot be reliably maintained.

NOTE — This clause applies to small isolated metal parts such as bolts, rivets, nameplates and cable clips. For the purposes of (c) above a major surface of the human body is considered to be 50 mm × 50 mm.

d) Fixing screws for non-metallic accessories provided that there is no appreciable risk of the screws coming into contact with live parts.

e) Short lengths of metal conduit for mechanical protection of cables having a non-metallic sheath, or other metal enclosures mechanically protecting equipment.

5.1.5 *Automatic Disconnection and Reduced System Voltages*

5.1.5.1 Where for functional reasons the use of extra-low voltage is impracticable and there is no requirement for the use of safety extra-low voltage, a reduced low voltage system may be used as specified in **5.1.5.2** to **5.1.5.7**.

5.1.5.2 The nominal voltage of the reduced low voltage circuit shall not exceed 110 V rms ac between phases (three phase 65 V to earthed neutral, single phase 55 V to earthed midpoint).

5.1.5.3 The source of supply to reduced low voltage circuits shall be one of the following:

— a double wound isolating transformer;

— a motor generator having windings providing isolation equivalent to that provided by the windings of an isolating transformer; or

— a source independent of other supplies, for example a diesel generator.

5.1.5.4 The neutral (star) point of the secondary windings of three-phase transformers and generators, or the midpoint of the secondary windings of single-phase transformers and generators, shall be connected to earth.

5.1.5.5 Protection against direct contact shall be provided by insulation or by barriers or enclosures.

5.1.5.6 Protection against indirect contact by automatic disconnection shall be provided by means of an overcurrent protective device in each phase conductor or by a residual current device, and all exposed conductive parts of the reduced low voltage system shall be connected to earth. The earth fault loop impedance at every point of utilisation, including socket outlets, shall be such that the disconnection time does not exceed 5 seconds. Where a residual current device is used, the product of the rated residual operating current in amperes and the earth fault loop impedance in ohms shall not exceed 50.

5.1.5.7 Plugs, socket outlets and cable couplers of reduced low voltage systems shall have a protective conductor contact and shall not be inter-changeable with plugs, socket outlets and cable couplers for use at other voltages in the same installation.

5.1.6 *Protective Measures for Particular Locations*— In certain locations the susceptibility of persons, and livestock where present, to electric shock may be so high as to necessitate special combinations of protective measures and supplementary precautions as specified in the following clauses.

5.1.6.1 *Bathrooms and showers*

a) In a room containing a fixed bath or shower, there shall be no socket outlets and there shall be no provision for connecting portable equipment. Where shower cubicles are located in rooms other than bathrooms, any socket outlets shall be situated at least 2·5 m from the shower cubicle. These requirements do not apply to shaver supply units complying with (d) below.

b) In a room containing a fixed bath or shower, supplementary equipotential bonding shall be provided between simultaneously accessible exposed conductive parts and simultaneously accessible extraneous conductive parts, and between simultaneously accessible extraneous conductive parts.

c) For circuits supplying equipment in a room containing a fixed bath or shower, where the equipment is simultaneously accessible with exposed conductive parts of other equipment or with extraneous conductive parts, the characteristics of the protective devices and the earthing arrangements shall be such that in the event of an earth fault, disconnection occurs within 0·4 seconds.

d) In a room containing a fixed bath or shower, electric shavers shall be connected only by means of a shaver supply unit complying with the relevant Indian Standard. The earthing terminal of the shaver supply unit shall be connected to the protective conductor of the final circuit from which the supply is derived.

e) In a room containing a fixed bath or shower cubicle, parts of a lampholder within a distance of 2·5 m from the bath or shower cubicle shall be constructed of or shrouded in insulating material. Bayonet type (B22) lampholder shall be fitted with a protective shield. As an alternative, totally enclosed luminaries may be used.

f) Every switch or other means of electrical control or adjustment shall be so situated as to be normally inaccessible to a person using a fixed bath or shower. This requirement does not apply to electric shaver supply units installed in accordance with (d) above or to insulating cords of cord-operated switches, or to controls incorporated in instantaneous water heaters. No stationary appliance having heating elements which can be touched shall be installed within reach of a person using the bath or shower. For the purpose of this standard the sheath of a silica glass sheathed element is regarded as part of the element.

5.1.6.2 *Agricultural installations*

a) In situations accessible to livestock in and around agricultural buildings, electrical equipment shall, so far as is practicable, be of Class II construction, or constructed of or protected by suitable insulation material.

Where protection against indirect contact is provided by automatic disconnection in such situations, the limiting values of earth fault loop impedance prescribed in **5.1.3.1** (a)(iv) are not applicable and shall be reduced as appropriate to the type of livestock whose presence is envisaged.

NOTE — The very low body resistance of horses and cattle, for example, makes them susceptible to electric shock at voltages lower than 25 V rms ac.

b) Where protection by the use of safety extra-low voltage is used in situations accessible to livestock in and around agricultural buildings, the upper limit of nominal voltage specified in **5.1.1.2** does not apply and shall be reduced as appropriate.

SECTION 3B PROTECTION AGAINST THERMAL EFFECTS

5.2 Requirements for Protection Against Thermal Effects

5.2.1 *General*

5.2.1.1 Protection against thermal effects caused by fixed electrical equipment shall be provided by the appropriate measures specified in this section.

5.2.1.2 All switchgear shall be selected and erected in accordance with the requirements of Section 4 so as to prevent danger from overheating, arcing, or the scattering of hot particles during operation.

5.2.2 *Protection Against Fire*

5.2.2.1 Fixed equipment shall be selected, located and erected so that its intended heat dissipation is not inhibited and it does not present a fire hazard to adjacent building materials.

5.2.2.2 Fixed equipment which in normal operation has a surface temperature exceeding 90°C shall be adequately ventilated and be mounted so that no material constituting a fire hazard is within 300 mm above or 150 mm laterally from or below the equipment (*see* Fig. 2), except that these distances may be reduced if a suitable fire-resistant shield or enclosure is installed between the equipment and any such material.

This does not apply to lamps, luminaires and appliances installed in accordance with the manufacturer's instructions and considered to comply with this requirement.

5.2.2.3 Where a distribution board is constructed without a back or without one or more of the other enclosing surfaces it shall be fitted only to surfaces of materials or to other equipment in such a way as to complete the enclosure.

5.2.2.4 All fixed luminaires and lamps shall be placed or guarded so as to prevent ignition of any material which in the conditions of use foreseen are likely to be placed in proximity to the luminaires or lamps. Any shade or guard used for this purpose shall be suitable to withstand the heat from the luminaire or lamp.

Fixed luminaires mounted in accordance with the manufacturer's installation instructions comply with this requirement.

Application of Protective Measure — *Under consideration.*

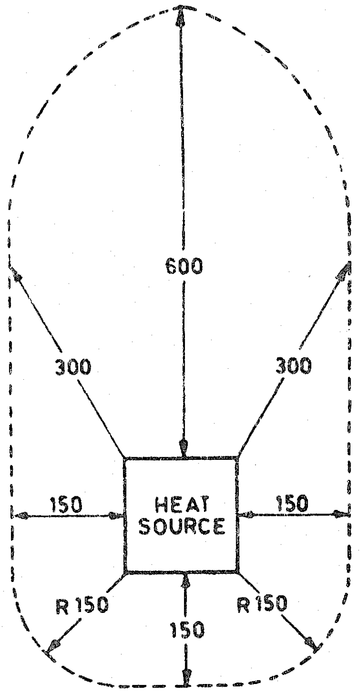

Fig. 2 Clearances from Equipment

5.2.3 *Protection Against Burns* — Where the temperature of any part of the enclosure of fixed equipment is liable to exceed 80°C, the enclosure shall be so located or guarded as to prevent accidental contact therewith.

SECTION 3C PROTECTION AGAINST OVERCURRENT

5.3 Requirements for Protection Against Overcurrent

5.3.1 *General*

5.3.1.1 Live conductors shall be protected by one or more devices for automatic interruption of the supply in the event of overload (*see* 5.3.3) and short circuits (*see* 5.3.4) except in cases where the overcurrent is limited in accordance with 5.3.6.

Note 1 — Live conductors protected against overload in accordance with 5.3.3 are considered to be protected also against faults likely to cause over currents of a magnitude similar to overload currents.

Note 2 — Protection of conductors in accordance with this clause does not necessarily protect the equipment connected to the conductors or flexible cables connecting such equipment to fixed installations through plugs and socket outlets.

5.3.1.2 The protection against overload and the protection against short circuits shall be coordinated in accordance with 5.3.5.

5.3.2 *Nature of Protective Devices*

5.3.2.1 *General* — The protective devices shall be of the appropriate types indicated in 5.3.2.2 to 5.3.2.4.

5.3.2.2 *Protection against both overload and short-circuit currents* — Devices providing protection against both overload current and short-circuit current shall be capable of breaking (and, for circuit breakers, making) any overcurrent up to and including the prospective short-circuit current at the point where the device is installed. They shall satisfy the requirements of 5.3.3 and 5.3.4.3 (b) and (c). Such protective devices may be circuit breakers incorporating overload release, or fuses, or circuit breakers in conjunction with fuses.

Note — The use of a projective device having rated breaking capacity below the value of the prospective short circuit current at its place of installation subject to the requirements of 5.3.4.3.b).

5.3.2.3 *Protection against overload current only*— Devices providing protection against overload currents shall satisfy the requirements of **5.3.3**. Such devices may have a breaking capacity below the value of the prospective short-circuit current at the point where the device is installed.

5.3.2.4 *Protection against short-circuit current only* — Devices providing protection against short-circuit currents shall satisfy the requirements of **5.3.4**. Such devices shall be capable of breaking (and, for circuit breakers, making) short-circuit currents up to and including the prospective short-circuit current. Such devices may be circuit breakers with short-circuit release, or fuses.

5.3.3 *Protection Against Overload Current*

5.3.3.1 Protective devices shall be provided to break any overload current flowing in the circuit conductors before such a current could cause a temperature rise detrimental to insulation, joints, terminations, or surroundings of the conductors.

5.3.3.2 *Coordination between conductors and protective devices* — The characteristics of a device protecting a circuit against overload shall satisfy the following conditions:

a) Its nominal current or current setting (I_n) is not less than the design current (I_B) of the circuit.

b) Its nominal current or current setting (I_n) does not exceed the lowest of the current carrying capacities (I_Z) of any of the conductors of the circuit.

c) The current causing effective operation of the protective device (I_2) does not exceed 1·45 times the lowest of the current carrying capacities (I_Z) of any of the conductors of the circuit.

Where the device is a fuse or a circuit breaker, compliance with condition (b) also results in compliance with condition (c).

Where the device is a semi-enclosed fuse, compliance with condition (c) is afforded if its nominal current (I_n) does not exceed 0·725 times the current-carrying capacity of the lowest rated conductor in the circuit protected.

NOTE 1 — The conditions of **5.3.3.2** may be stated as formulae as follow:

$$I_B \leqslant I_n < I_Z$$

$$I_2 \leqslant 1 \cdot 45 \times I_Z$$

NOTE 2 — It is expected that the circuit is so designed that small overloads of long duration will not frequently occur (*see* **3.1.1**).

5.3.3.3 *Protection of conductors in parallel* — When the same protective device protects conductors in parallel, the value of I_Z is the sum of the current-carrying capacities of those conductors. This provision is applicable only if those conductors are of the same type, cross-sectional area, length and disposition, have no branch circuits throughout their length and are arranged so as to carry substantially equal currents. This does not apply to ring circuits.

Application of protective measure against overcurrent

a) *Position of devices for overload protection*

   i) *A device for protection against overload shall be placed at the point where a reduction occurs in the value of current-carrying capacity of the conductors of the installation. This requirement does not apply where the arrangements mentioned in* (ii) *below are adopted, and no overload protective device need be provided where* (b) *below applies.*

   NOTE—A reduction in the value of current-carrying capacity may be caused by a change in cross-sectional area, method of installation, type of cable or conductor, or in environmental conditions.

   ii) *The device protecting conductors against overload may be placed along the run of those conductors, provided that the part of run between the point where the value of current-carrying capacity is reduced and the position of the protective device has no branch circuits or outlets for the connection of current-using equipment.*

b) *Omission of devices for overload protection — Devices for protection against overload need not be provided for:*

   i) *conductors situated on the load side of the point where a reduction occurs in the value of current-carrying capacity, where the conductors are effectively protected against overload by a protective device placed on the supply side of that point;*

   ii) *conductors which because of the characteristics of the load, are not likely to carry overload current;*

   iii) *circuits supplying equipment where unexpected opening of the circuit could cause a greater danger than an overload condition, for example, supply circuits of lifting magnets, exciter circuits of rotating machines; and*

   iv) *secondary circuits of current transformers.*

   NOTE — The omission of overload protection is recommended for the circuits described in (iii) above, but in such cases the provision of an overload alarm should be considered.

c) *Overload protective device in IT systems*

   i) *The provisions of* (a)(ii) *and* (b) *are applicable to installations forming part of an IT system, only where the conductors concerned are protected by a residual current protective device, or all the equipment supplied by the circuit concerned (including the conductors) complies with the protective measure described in* **5.1.3.2**.

5.3.4 *Protection Against Short-Circuit Current* — This clause deals only with the case of short circuits anticipated between conductors belonging to the same circuit.

5.3.4.1 *General* — Protective devices shall be provided to break any short-ciruit current in the conductors of each circuit before such current could cause danger due to thermal and mechanical effects produced in conductors and connections. The nominal current of such a protective device may be greater than current-carrying capacity of the conductor being protected.

5.3.4.2 *Determination of prospective short-circuit current* — The prospective short-circuit current at every relevant point of the complete installation shall be determined. This may be done either by calculation or by measurement of the relevant impedances.

NOTE — If the prospective short-circuit current at the origin of an installation is less than the breaking capacity rating of the smallest rated protective device to be used in the installation, no further assessment of the prospective short-circuit current is necessary.

5.3.4.3 *Characteristics of short-circuit protective devices*

a) Each short-circuit protective device shall meet the requirements of (b) and (c) below;

b) The breaking capacity rating shall be not less than the prospective short-circuit current at the point at which the device is installed.

A lower breaking capacity is permitted if another protective device having the necessary breaking capacity is installed on the supply side. In that case the characteristics of the devices shall be coordinated so that the energy let-through of these two devices does not exceed that which can be withstood without damage by the device on the load side and the conductors protected by these devices.

Other characteristics may need to be taken into account, such as dynamic stresses and arcing energy, for the device on the load side.

NOTE — Details of the characteristics needing coordination should be obtained from the manufacturers of the devices concerned. Coordination with regard to their operating times is of importance.

c) Where an overload protective device complying with 5.3.3 is to be used also for short circuit protection, and has a rated breaking capacity not less than the value of the prospective short-circuit current at its point of installation, it may generally be assumed that the requirements are satisfied as regards short-circuit protection of the conductor on the load side of that point.

NOTE — For certain types of circuit breakers, especially non-current-limiting types, this assumption may not be valid for the whole range of short-circuit currents; in case of doubt, its validity should be checked in accordance with the requirements of (d) below.

d) Where (c) above does not apply, it shall be verified as follows that all currents caused by a short-circuit occurring at any point of the circuit shall be interrupted in a time not exceeding that which brings the cable conductors to the admissible limiting temperature. In addition it shall be verified for larger installations that the cable is unlikely to be damaged mechanically.

For short-circuits of duration up to 5 seconds the time t in which a given short-circuit current will raise the conductors from the highest permissible temperature in normal duty to the limit temperature, can as an approximation be calculated from the formula:

$$t = \frac{k^2 S^2}{I^2}$$

where

t = duration in seconds;

S = cross-sectional area in mm²;

I = effective short-circuit current in amperes expressed, for ac, as the rms value;

k = 115 for copper conductors insulated with PVC;

134 for copper conductors insulated with 60°C rubber, 85°C rubber;

143 for copper conductors with 90°C thermosetting insulation;

108 for copper conductors insulated with impregnated paper;

135 for mineral-insulated cables with copper conductors;

76 for aluminium conductors insulated with PVC;

89 for aluminium conductors insulated with 60°C rubber, 85°C rubber;

94 for aluminium conductors with 90°C thermosetting insulation;

71 for aluminium conductors insulated with impregnated paper;

87 for mineral-insulated cables with aluminium conductors;

100 for tin-soldered joints in copper conductors, corresponding to a temperature of 160°C.

NOTE — For very short durations (less than 0·1 second) where a symmetry of the current is of importance and for current limiting devices, the value of k^2S^2 for the cable should be greater than the value of let-through energy (I^2t) of the device as quoted by the manufacturer.

5.3.4.4 *Protection of conductors in parallel* — A single device may protect several conductors in parallel against short circuit provided that the operating characteristics of the device and the method of installation of the parallel conductors are suitably coordinated.

NOTE — Account should be taken of the conditions that would occur in the event of a short circuit which does not affect all of the conductors.

Application of protective measure 5.3.4

a) *Position of devices for short-circuit protection*

i) *A devices for protectivn against short-circuit shall be placed at the point where a reduction occurs in the value of current-carrying capacity of the conductors of the installation. This requirement does not apply where the arrangements mentioned in* (ii) *or* (iii) *below are adopted, and no short-circuit protective device need be provided where* (b) *below applies.*

NOTE — A reduction in the value of current-carrying capacity may be caused by a change in cross-sectional area, method of installation, type of cable or conductor, or in environmental conditions.

ii) *The short-circuit protective device may be placed at a point on the load side of that specified in* (i) *under the following conditions: between the point where the value of current-carrying capacity is reduced and the position of the protective device, the conductors shall:*

1) *not exceed 3 m in length,*

2) *be erected in such a manner as to reduce the risk of short circuit to a minimum, and*

3) *be erected in such a manner as to reduce the risk of fire or danger to persons to a minimum.*

NOTE 1 — The condition specified in (2) above may be fulfilled for example, by reinforcing the protection of the conductors against external influences.

NOTE 2 — The provisions of (ii) cannot be applied to any part of an installation in respect of which the short circuit protective device is intended also to afford protection against indirect contact.

iii) *The short-circuit protective device may be placed at a point other than that specified in* (i), *where a protective device on the supply side of that point possesses an operating characteristic such that it protects against short circuit, in accordance with* **5.3.4.3**(d), *the conductors on the load side of that point.*

b) *Omission of devices for short-circuit protection*

i) *Devices for protection against short circuit need not be provided for:*

1) *conductors connecting generators, transformers, rectifiers or batteries with their control panels, where short-circuit protective devices are placed on those panels,*

2) *certain measuring circuits, and*

3) *circuits where disconnection could cause danger in the operation the installation concerned.*

Provided that the conductors thus not protected against short circuit comply with the conditions specified in (a)(ii)(2) *and* (3) *above.*

5.3.5 *Coordination of Overload and Short-Circuit Protection* — The characteristics of devices for overload protection and those for short-circuit protection shall be coordinated so that the energy let-through by the short-circuit protective device does not exceed that which can be withstood without damage by the overload protective device.

NOTE — For circuits incorporating motor starters, the advice of the manufacturer of the starter should be sought.

5.3.6 *Limitation of Overcurrent by Characteristics of Supply* — Conductors are considered to be protected against overload and short-circuit currents where they are supplied from a source incapable of supplying a current exceeding the current carrying capacity of the conductors.

5.3.7 *Protection According to the Nature of Circuits and Distribution System*

5.3.7.1 *Phase conductors* — Means of detection of overcurrent shall be provided for each phase conductor, and shall cause the disconnection of the conductor in which the overcurrent is detected, but not necessarily the disconnection of other live conductors. Where the disconnection of one phase could cause danger, for example in the supply to three-phase motors, appropriate precautions shall be taken.

5.3.7.2 *Neutral conductor — TN or TT systems*

a) In TN or TT systems, where the cross-sectional area of the neutral contractor is less than that of the phase conductors, overcurrent detection for the neutral conductor shall be provided unless both the following conditions are satisfied:

i) the neutral conductor is protected against short circuit by the protective device for the phase conductor of the circuit,

ii) the load is shared as evenly as possible between the various phases of the circuit.

b) Where either or both of the conditions specified in (b) above are not met, overcurrent detection shall be provided for the neutral conductor, appropriate to the cross-sectional area of that conductor, and the means of detection shall cause the disconnection of the phase conductors but not necessarily of the neutral conductor.

NOTE — The cross-sectioal area of the neutral conductor should in any event comply with Section 4.

5.3.7.3 *Neutral conductor—IT systems*

a) In IT systems, the distribution of the neutral conductor shall be avoided wherever practicable. Where distribution of the neutral conductor is unavoidable, means of detection of overcurrent shall be provided for the neutral conductor of every circuit, which shall cause disconnection of all the live conductors of the circuit concerned including the neutral conductor. This requirement does not apply where the arrangements described in (b) below are adopted.

b) In IT systems where the neutral is distributed, means of detection of overcurrent for the neutral conductor need not be provided if either of the following conditions is satisfied:
   i) the neutral conductor concerned is effectively protected against short circuit by a protective device placed on the supply side, for example at the origin of the installation, in accordance with the requirements of **5.3.4.3**(b); and
   ii) the circuit concerned is protected by a residual current device having a rated residual operating current not exceeding 0·15 times the current-carrying capacity of the neutral conductor concerned and the device is arranged to disconnect all the live conductor of the circuit concerned including the neutral conductor.

SECTION 3D PROTECTION AGAINST OVERVOLTAGE

5.4 Requirements for Protection Against Overvoltage — *Under consideration.*

NOTE — This clause is set aside to cover rules concerning protective measures against overvoltage which could be due to several reasons such as:

a) insulation fault between live parts of circuits supplied at different voltages, and
b) atmospheric phenomena or switching voltages.

SECTION 3E PROTECTION AGAINST UNDERVOLTAGE

5.5 Requirements for Protection Against Undervoltage

5.5.1 *General Requirements*

5.5.1.1 Where a drop in voltage, or a loss and subsequent restoration of voltage could imply dangerous situations for persons or property, suitable precautions shall be taken. Also, precautions shall be taken where a part of the installation or current-using equipment may be damaged by a drop in voltage.

An undervoltage protective device is not required if damage to the installation or to current-using equipment is considered to be an acceptable risk, provided that no danger is caused to persons.

5.5.1.2 The operation of undervoltage protective devices may be delayed if the operation of the appliance protected allows without danger a brief interruption or loss of voltage.

5.5.1.3 If use is made of contractors, delay in their opening and reclosing shall not impede instantaneous disconnection by control or protective devices.

5.5.1.4 The characteristics of the undervoltage protective device shall be compatible with the requirements of the Indian Standards for starting and use of equipment.

5.5.1.5 Where the reclosure of a protective device is likely to create a dangerous situation, the reclosure shall not be automatic.

Application of protective measure **5.5** — *Under consideration.*

SECTION 3F ISOLATION AND SWITCHING

5.6 Requirements for Isolation and Switching

5.6.0 *General*

5.6.0.1 Means shall be provided for non-automatic isolation and switching to prevent or remove hazards associated with the electrical installation or electrically powered equipment and machines. These means shall comply with the appropriate requirements of this section.

5.6.0.2 In TN-C systems the PEN conductor shall not incorporate means of isolation or switching. In TN-S systems the protective conductor shall not incorporate a means of isolation or switching and provision need not be made for isolation of the neutral conductor except where this is specifically required.

Application of protective measure — Isolation and switching

Every installation shall be provided with means of isolation. In addition, means of electrical switching off for mechanical maintenance, or means of emergency switching, or both shall be provided for any parts of the installation to which Section 4 applies.

Where more than one of these functions are to be performed by a common device, the arrangement and characteristics of the device shall satisfy all the requirements of these clauses for the various functions concerned. Devices for functional switching may serve also for isolation, switching off for mechanical maintenance or emergency switching where they satisfy the relevant requirements.

NOTE — Clauses for selection and erection of devices for isolation and switching are contained in Section 4.

5.6.1 *Isolation*

5.6.1.1 Every circuit shall be provided with means of isolation from each of the live supply conductors, except as provided in **5.6.0.2**. It is permissible to isolate a group of circuits by a common means, due consideration being given to service conditions.

5.6.1.2 Adequate provision shall be made so that precautions can be taken to prevent any equipment from being unintentionally energised.

5.6.1.3 Where an item of equipment or enclosure contains live parts that are not capable of being isolated by a single device, a warning notice shall be placed in such a position that any person gaining access to live parts will be warned of the need to use the appropriate isolating devices, unless an interlocking arrangement is provided so that all the circuits concerned are isolated.

5.6.1.4 Where necessary to prevent danger, adequate means shall be provided for the discharge of capacitive electrical energy.

5.6.1.5 All devices used for isolation shall be clearly identifiable for example, by marking, to indicate the circuit which they isolate.

Application for protective measure—Isolation

a) *Means of isolation complying with* **5.6.1** *shall be provided at a point as near as practicable to the origin of every installation, without the intervention of any other equipment on which work might need to be done.*

b) *Where an isolator is to be used in conjunction with a circuit-breaker as a means of isolating main switchgear for maintenance, it shall be interlocked with the circuit-breaker; alternatively, it shall be so placed and/or guarded that it can be operated only by skilled persons.*

c) *Where isolating devices for particular circuits are placed remotely from the equipment to be isolated, provision shall be made that the means of isolation can be secured against inadvertent reclosure during the operation for which it is intended. Where this provision takes the form of a lock or removable handle, the key or handle shall be non-interchangeable with any other used for a similar purpose within the installation.*

d) *Every motor circuit shall be provided with an isolating device or devices which shall disconnect the motor and all equipment, including any automatic circuit-breaker, used therewith.*

e) *For electric discharge lighting installations using an open-circuit voltage exceeding low voltage, one or more of the following means shall be provided for the isolation of every self-contained luminaire, or alternatively of every circuit supplying luminaires at a voltage exceeding low voltage:*

   i) *an interlock on a self contained luminaire, so arranged that before access can be had to live parts the supply is automatically disconnected, such means being additional to the switch normally used for controlling the circuit,*

   ii) *effective local means for the isolation of the circuit from the supply, such means being additional to the switch normally used controlling the circuit, and*

   iii) *a switch having a lock or removable handle, or a distribution board which can be locked, in either case complying with* (c) *above.*

5.6.2 *Switching Off for Mechanical Maintenance*

5.6.2.1 Means of switching off for mechanical maintenance shall be provided where mechanical maintenance may involve a risk of physical injury.

5.6.2.2 Devices for switching off for mechanical maintenance shall be suitably placed, readily identifiable (for example by marking if necessary) and convenient for their intended use.

5.6.2.3 Suitable means shall be provided so that precautions can be taken to prevent any equipment from being unintentionally or inadvertently reactivated.

Application of protective measure prescribed in 5.6.2

A means of switching off for mechanical maintenance shall be provided for every circuit supplying an electric motor, or equipment having electrically heated surfaces which can be touched, or electromagnetic equipment for operations from which mechanical accidents could arise.

Where a switch mounted on an appliance or luminaire is intended to serve as a means of switching off for mechanical maintenance, the connections shall be so arranged that the appliance or luminaire can be dismantled to the extent necessary for mechanical maintenance without thereby exposing any parts which remain live when the switch is open. Any conductors or cables which then remain live shall be as short as possible, and separated from any other live conductors or cables by screens or earthed metal or suitable barriers of insulating material.

5.6.3 *Emergency Switching*

5.6.3.1 For every part of an installation which it may be necessary to disconnect rapidly from the supply in order to prevent or remove a hazard, a means of emergency switching shall be provided.

5.6.3.2 Means for emergency switching shall act as directly as possible on the appropriate supply conductors, and shall be such that a single initiative action will cut off the appropriate supply.

5.6.3.3 The arrangement of emergency switching shall be such that its operation does not introduce a further hazard or interfere with the complete operation necessary to remove the hazard.

5.6.3.4 Devices for emergency switching shall be readily accessible and suitably marked.

5.6.3.5 Means of emergency stopping shall be provided where movements by electrical means may give rise to danger.

Application of protective measure—Emergency switching

a) *For every emergency switching device, account shall be taken of the intended use of the premises so that access to the device is not likely to be impeded in the conditions of emergency foreseen.*

b) *Where greater danger would arise from incorrect operation of emergency switching (as for example by inadvertent disconnection of safety services), the means of emergency switching may be arranged so as to be suitable for operation by skilled persons or instructed persons only.*

c) *Means of emergency switching shall be provided in every place where a machine driven by electric means may give rise to danger, and shall be readily accessible and easily operated by the person in charge of the machine. Where more than one means of manually stopping the machine is provided and danger might be caused by unexpected restarting, means shall be provided to prevent such restarting.*

d) *A fireman's emergency switch shall be provided for:*

- *exterior discharge lighting installations operating at a voltage exceeding low voltage, and*
- *interior discharge lighting installations operating unattended at a voltage exceeding low voltage.*

For the purpose of this requirement, an installation in a closed market or in an arcade is considered to be an exterior installation. A temporary installation in a permanent building used for exhibitions is considered not to be an exterior installation. This requirement does not apply to a portable discharge lighting luminaire or sign of rating not exceeding 100 W and fed from a readily accessible socket outlet.

e) *Every fireman's emergency switch provided for compliance with (d) shall comply with all the relevant requirements of the following items:*

i) *For exterior installations, the switch shall be outside the building and adjacent to the discharge lamp(s), or alternatively a notice indicating the position of the switch shall be placed adjacent to the discharge lamp(s) and a nameplate shall be fixed near the switch so as to render it clearly distinguishable.*

ii) *For interior installations, the switch shall be in the main entrance to the building or in another position to be agreed with the local fire authority.*

iii) *The switch shall be placed in a conspicuous position, reasonably accessible to firemen and except where otherwise agreed with the local fire authority, at not more than 2·75 m from the ground.*

iv) *Where more than one switch is installed on any one buiding, each switch shall be clearly marked to indicate the installation or part of the installation which it controls, and the local fire authority shall be notified accordingly.*

Note — Wherever practicable, all exterior installations on any one building should be controlled by a single fireman's switch. Similarly all internal installations in any one building should be controlled by a single fireman's switch independent of the switch for any external installation.

5.6.4 *Other Requirements for Switching for Safety*

5.6.4.1 In situations where the requirements of 5.6.3 for emergency switching are not applicable, the requirements of 5.6.4.2 to 5.6.4.7 shall be satisfied, either:

- by means of isolation and/or the means of switching off for mechanical maintenance provided for compliance with 5.6.1 and 5.6.2, or
- by the arrangements for switching of equipment for its normal service (functional switching), or
- by the provision of suitable additional means of switching.

5.6.4.2 A main switch or circuit-breaker shall be provided for every installation which shall interrupt all live conductors of the installation, provided that for a 4-wire three-phase ac supply the linked switch or linked circuit-breaker may be arranged to disconnect the phase conductors only and a link may be inserted in the neutral conductor; such a link shall be arranged such that it is in contact before the linked switch can be closed, or shall be securely fixed by bolts or screws.

5.6.4.3 Every circuit and final circuit shall be provided with means of interrupting the supply on load and in any fault conditions foreseen. A group of circuits may be switched by a common device. Additionally, such means shall be provided for every circuit or other part of the installation which it may be necessary for safety reasons to switch independently of other circuits or other parts of the installation. This regulation does not apply to short connections between the origin of the installation and the consumer's main switchgear.

5.6.4.4 Every appliance or luminaire connected to the supply other than by means of a plug and socket outlet complying with Section 4, shall be provided with a means of interrupting the supply on load. The means of interruption shall be separate from the appliance and in a readily accessible position, subject to the provisions of 5.6.4.5 and 5.6.4.6 where applicable. For an appliance fitted with heating elements which can be touched, the means of interruption shall be a linked switch arranged to break all the circuit conductors including the neutral. For the purpose of this regulation the sheath of silica-glass sheathed element is regarded as part of the element. Where the means of interruption is also intended to serve as a means of switching off for mechanical maintenance, it shall comply with the requirements of Section 4.

5.6.4.5 The means of interrupting the supply required by 5.6.4.4 may be a device mounted on the appliance or luminaire, as in 5.6.2 where the device is intended to serve as a means of switching off for mechanical maintenance.

5.6.4.6 The means of interrupting the supply on load to comprehensive heating or lighting installations comprising more than one appliance or luminaire, may be installed in separate room.

5.6.4.7 Every fixed or stationary household cooking appliance shall be controlled by a switch separate from the appliance and placed within 2 m of the appliance. Where two stationary cooking appliances are installed in one room of household premises, one switch may be used to control both appliances provided that neither appliance is more than 2 m from the switch.

SECTION 4 DESIGN OF INSTALLATION, SELECTION AND ERECTION OF EQUIPMENT

6. FUNDAMENTAL REQUIREMENTS

6.1 Fundamental Requirements for Design

6.1.0 For the design of the electrical installation, the following factors shall be taken into account to ensure:

a) the protection of persons, livestock and property in accordance with Section 3, and

b) the proper functioning of the electrical installation for the use intended.

The information required as the basis for design of installation and selection of equipment are stated below.

6.1.1 Characteristics of the available supply or supplies:

a) Nature of current: ac or dc or both

b) Nature and number of conductors:
   i) For ac : phase conductors
      neutral conductors
      protective conductors
   ii) For dc : conductors equivalent to those listed for ac

c) Values and tolerances:
   i) Voltage and voltage tolerances
   ii) Frequncy and frequency tolerances
   iii) Maximum current allowable
   iv) Prospective short-circuit current

d) Power factor

e) Protective measures inherent in the supply, for example, earthed (grounded) neutral or mid-wire

f) Particular requirements of the supply undertaking.

g) Particular requirements of the load.

6.1.2 *Nature of Demand* — The number and type of the circuits required for lighting, heating, power, control, signalling, telecommunication, etc, are to be determined by:

a) location of points of power demand,

b) loads to be expected on the various circuits,

c) daily and yearly variation of demand,

d) any special conditions, and

e) requirements for control, signalling, telecommunication, etc.

6.1.3 *Emergency Supply or Supplies*

a) Source of supply (nature, characteristics), and

b) Circuits to be supplied by the emergency source.

6.1.4 *Environmental Conditions — See* 4.

6.1.5 *Cross Section of Conductors* — The cross section of conductors shall be determined according to:

a) their admissible maximum temperature,

b) the admissible voltage drop,

c) the electromechanical stresses likely to occur due to short circuits,

d) other mechanical stresses to which the conductors may be exposed, and

e) the maximum impedance with respect to the functioning of the short-circuit protection.

NOTE — The above listed items concern primarily the safety of electrical installations. Cross-sectional areas greater than those required for safety may be desirable for economic operation.

6.1.6 *Type of Wiring and Methods of Installation*— The choice of the type of wiring and the methods of installation depend on:

a) the nature of the locations,

b) the nature of the walls or other parts of the building supporting the wiring,

c) accessibility of wiring to persons and livestock,

d) voltage,

e) the electromechanical stresses likely to occur due to short circuits, and

f) other stresses to which the wiring may be exposed during the erection of the electrical installation or in service.

6.1.7 *Protective Equipment* — The characteristics of protective equipment shall be determined with respect to their function which may be for example, protection against the effects of:

a) overcurrent (overload and short circuit),

b) earth-fault current,

c) overvoltage, and

d) undervoltage and no-voltage.

The protective devices shall operate at values of current voltage and time which are suitably related to the characteristics of the circuits and to the possibilities of danger.

6.1.7.1 *Position of protective devices and switches*

a) No fuse, or circuit-breaker other than a linked circuit-breaker, shall be inserted in an earthed neutral conductor, and any linked circuit-breaker inserted in an earthed neutral conductor shall be arranged to break also all the related phase conductors.

b) Every single pole switch shall be inserted in the phase conductor only, and any switch connected in an earthed neutral conductor shall be a linked switch and shall be arranged to break also all the related phase conductors.

c) Effective means, suitably placed for ready operation, shall be provided so that all voltage may be cut off from every installation, from every circuit thereof and from all equipment, as may be necessary to prevent or remove danger.

NOTE — Where the supply undertaking provide switchgear or fusegear at the origin of the installation it may not be necessary to duplicate the means of isolation for that part of the installation between its origin and the main distribution point of the installation where the next step for isolation is provided (*see* 5.0.4.1). In domestic installations the isolating and protection functions are combined in the same device.

d) For every electric motor an efficient means of disconnection shall be provided which shall be readily accessible, easily operated and so placed as to prevent danger.

6.1.8 *Emergency Control* — Where, in case of danger, there is necessity for immediate interruption of supply, an interrupting device shall be installed in such a way that it can be easily recognized and effectively and rapidly operated.

6.1.9 *Disconnecting Devices* — Disconnecting devices shall be provided so as to permit disconnection of the electrical installation, circuits or individual items of apparatus as required for maintenance, testing, fault detection or repair.

6.1.10 *Prevention of Mutual Influence between Electrical and Non-electrical Installations* — The electrical installation shall be arranged in such a way that no mutual detrimental influence will occur between the electrical installation and non-electrical installations of the building.

6.1.11 *Accessibility of Electrical Equipment* — The electrical equipment shall be arranged so as to afford:

a) sufficient space for the initial installation and later replacement of individual items of electrical equipment; and

b) accessibility for operation, testing, inspection, maintenance and repair.

6.2 Fundamental Requirements for Selection of Electrical Equipment

6.2.0 Every item of electrical equipment used in electrical installations shall comply with relevant Indian Standard specifications.

6.2.1 *Characteristics* — Every item of electrical equipment selected shall have suitable characteristics appropriate to the values and conditions on which the design of the electrical installation (*see* 6.1) is based and shall, in particular, fulfil the following requirements.

6.2.1.1 *Voltage* — Electrical equipment shall be suitable with respect to the maximum steady voltage (rms value for ac) likely to be applied, as well as overvoltages likely to occur.

NOTE — For certain equipment, it may be necessary to take account of the lowest voltage likely to occur.

6.2.1.2 *Current* — All electrical equipment shall be selected with respect to the maximum steady current (rms value for ac) which it has to carry in normal service, and with respect to the current likely to be carried in abnormal conditions and the period (for example, operating time of protective devices if any) during which it may be expected to flow.

6.2.1.3 *Frequency* — If frequency has an influence on the characteristics of electrical equipment, the rated frequency of the equipment shall correspond to the frequency likely to occur in the circuit.

6.2.1.4 *Power* — All electrical equipment, to be selected on the basis of its power characteristics, shall be suitable for the duty demanded of the equipment, taking into account the load factor and the normal service conditions.

6.2.2 *Conditions of Installation* — All electrical equipment shall be selected so as to withstand safely the stresses and the environmental conditions (*see* 4) characteristic of its location and to which it may be exposed. If, however, an item of equipment does not have by design the properties corresponding to its location, it may be used on condition that adequate additional protection is provided as part of the completed electrical installation.

6.2.3 *Prevention of Harmful Effects* — All electrical equipment shall be selected so that it will not cause harmful effects on other equipment or impair the supply during normal service including switching operations. In this context, the factors which may have an influence include, for example:

a) power factor,

b) inrush current,

c) asymmetrical load, and

d) harmonics.

6.3 Fundamental Requirements for Erection and Initial Testing of Electrical Installations

6.3.1 *Erection*

6.3.1.1 For the erection of the electrical installation good workmanship by suitably qualified personnel and the use of proper materials shall be provided for.

6.3.1.2 The characteristics of the electrical equipment, as determined in accordance with 6.2, shall not be impaired in the process of erection.

6.3.1.3 Protective conductors and neutral conductors shall be identifiable at least at their terminations by colouring or other means. These conductors in flexible cords or flexible cables shall be identifiable by colouring or other means throughout their length.

6.3.1.4 Connections between conductors and between conductors and other electrical equipment shall be made in such a way that safe and reliable contact is ensured.

6.3.1.5 All electrical equipment shall be installed in such a manner that the designed cooling conditions are not impaired.

6.3.1.6 All electrical equipment likely to cause high temperatures or electric arcs shall be placed or guarded so as to eliminate the risk of ignition of flammable materials. Where the temperature of any exposed parts of electrical equipment is likely to cause injury to persons, those parts shall be so located or guarded as to prevent accidental contact therewith.

7. COMMON RULES

7.0 General — Every item of equipment shall be selected and erected so as to comply with the requirements stated in this code.

7.1 Compliance with Standards — All equipment fittings and accessories, materials, etc, selected for the wiring installation shall conform to the relevant Indian Standard.

7.2 Operational Conditions and External Influences

7.2.1 *Voltage* — All equipment shall be suitable for the nominal voltage (rms value for ac) of the installation.

In an IT system, if the neutral conductor is distributed, equipment connected between phase and neutral shall be insulated for the nominal voltage between phases.

NOTE 1 — Where inductive or capacitive equipment is concerned, the design of switches and circuit breakers should be adequate for such service.

NOTE 2 — For certain equipment, it may be necessary to take account of the highest and/or lowest voltage likely to occur in normal service.

7.2.2 *Current* — All equipment shall be suitable for:

a) the design current (rms value for ac), and
b) the current likely to flow in abnormal conditions for such periods of time as are determined by the characteristics of the protective devices concerned.

NOTE — Where inductive or capacitive equipment is concerned, the design of switches and circuit-breakers should be adequate for such service.

7.2.3 *Frequency* — If frequency has an influence on the characteristics of the equipment, the rated frequency of the equipment shall correspond to the frequency of the current in the circuit concerned.

7.2.4 *Power* — Equipment to be selected on the basis of its power characteristics shall be suitable for the duty demanded of the equipment, taking into account the load factor and the normal operational conditions.

7.2.5 *Compatibility* — All equipment shall be selected and erected so that it will not cause harmful effects on other equipment or impair the supply during normal service including switching operations.

7.2.6 *External Influences*— All equipment shall be of a design appropriate to the situation in which it is to be used and its mode of installation shall take into account the conditions likely to be encountered.

7.3 Accessibility

7.3.1 All equipment shall be arranged so as to facilitate its operation, inspection and maintenance and access to its connections. Such facilities shall not be significantly impaired by mounting equipment in enclosures or compartments.

7.4 Identification and Notices

7.4.1 *General* — Labels or other suitable means of identification shall be provided to indicate the purpose of switchgear and controlgear, unless there is no possibility of confusion.

Where the operation of switchgear and controlgear cannot be observed by the operator and where this might cause a danger, a suitable indicator, complying with IS : 7118-1973* where applicable, shall be fixed in a position visible to the operator.

7.4.2 *Protective Devices* — Protective devices shall be arranged and identified so that the circuits protected may be easily recognized; for this purpose it may be convenient to group them in distribution boards.

7.4.3 *Diagrams* — Diagrams, charts or tables shall be provided indicating in particular:

a) the type and composition of circuits (points of utilization served, number and size of conductors, type of wiring); and
b) the information necessary for the identification of the devices performing the functions of protection, isolation and switching, and their locations.

For simple installations the foregoing information may be given in a schedule.

7.4.4 *Warning Notices — Voltage* — Every item of equipment or enclosure within which a voltage exceeding 250 volts exists, and where the presence of such a voltage would not normally be expected, shall be so arranged that before access is gained to live parts, a warning of the maximum voltage present is clearly visible (*see* IS : 2551-1982†).

Where terminals or other fixed live parts between which a voltage exceeding 250 volts exists are housed in separate enclosures or items of equipment which, although separated, can be reached simultaneously by a person, a notice shall be placed in such a position that anyone gaining access to live parts is warned of the maximum voltage which exists between those parts.

Means of access to all live parts of switchgear and other fixed live parts where different nominal voltages exist shall be marked to indicate the voltage present.

7.5 Mutual Detrimental Influence

7.5.1 All electrical equipment shall be selected and erected so as to avoid any harmful influence between the electrical installation and any non-electrical installations envisaged.

7.5.2 Where equipment carrying currents of different types or at different voltages is grouped in a common assembly, all equipment using any one type of current or any one voltage shall, wherever necessary, be effectively segregated from equipment of any other type, to avoid mutual detrimental influence.

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*Recommendations for direction of movement for control devices operating electrical apparatus.

†Danger notice plates (*first revision*).

8. CABLES, CONDUCTORS AND WIRING MATERIALS

8.1 Selection of Types of Wiring Systems

8.1.1 *Non-flexible Cables and Conductors for Low Voltages*

8.1.1.1 Every non-flexible cable operating at low voltage selected from one of the recognized types conforming to relevant Indian Standard.

8.1.1.2 Paper-insulated cables shall be of a type which will comply with the requirements of IS : 692-1973* for non-draining cables, where drainage of the impregnating compound would otherwise be liable to occur.

8.1.1.3 Busbars and busbar connections shall comply with IS : 8623 (Part 1)-1977†.

8.1.1.4 Every conductor, other than a cable, for use recognized as an overhead line operating at low voltage shall be selected from one of the recognized types and shall comply with the appropriate Indian Standard.

8.1.2 *Flexible Cables and Flexible Cords for Low Voltage*

8.1.2.1 Every flexible cable recognized and flexible cord for use at low voltage shall be selected from one of the recognized types and shall comply with the appropriate Indian Standard.

8.1.3 *Cables for Extra-Low Voltage* — Cables for use at extra-low voltage shall have adequate insulation, and further protection if necessary, so as to prevent danger.

8.1.4 *Cables for AC Circuits — Electromagnetic Effects* — Conductors of ac circuits installed in ferrous enclosures shall be arranged so that the conductors of all phases and the neutral conductor (if any) are contained in the same enclosure. Where such conductors enter ferrous enclosures they shall be arranged so that the conductors are not separated by a ferrous material or provisions shall be made to prevent circulating eddy currents.

8.1.5 *Conduits and Conduit Fittings*

8.1.5.1 Conduits and conduit fittings shall comply with the appropriate Indian Standard.

8.1.5.2 In conduit systems, the conduits for each circuit shall be completely erected before any cable is drawn in. This requirement does not apply to prefabricated conduit systems which are not wired *in situ*.

8.1.5.3 In the prefabrication of conduit systems which are not to be wired *in situ*, adequate allowance shall be made for variations in building dimensions so that the conduits or cables are not subjected to tension or other mechanical strain during installation. Adequate precautions shall also be taken to prevent damage to such systems during installation and any subsequent building operations, especially against deformation of the conduits and damage to any exposed cable ends.

8.1.6 *Trunking, Ducting and Fittings* — Trunking, ducting and fittings shall comply, where applicable with the relevant Indian Standard.

8.1.7 *Methods af Installation of Cables and Conductors*

8.1.7.1 Methods of installation of cables and conductors in common use for which this code specifically provide are described in Appendix A. The use of other methods is not precluded, provided that the applicable requirements of this section are complied with.

8.1.7.2 Ducts cast *in situ* in concrete, by means of a suitable form laid before the concrete is poured, into which cables are to be drawn (whether or not formers are retained in position after the concrete has set) shall be so formed that the radial thickness of concrete or screed surrounding the cross section of the completed duct is not less than 15 mm at every point.

8.2 Operation Conditions

8.2.1 *Current-Carrying Capacity*

8.2.1.1 The cross-sectional area of every cable conductor shall be such that its current-carrying capacity is not less than the maximum sustained current which will normally flow through it. For the purposes of this clause the limiting temperature to which the current-carrying capacity relates shall not exceed that appropriate to the type of cable insulation concerned. This does not apply to conductors on switchboards complying with **8.2.2**.

8.2.1.2 Busbars, busbar connections and bare conductors forming part of the equipment of switchboards shall comply as regards current-carrying capacity and limits of temperature with the requirements of IS : 8623 (Part 1)-1977*.

8.2.1.3 Cables connected in parallel shall be of the same type, cross-sectional area, length and disposition and be arranged so as to carry substantially equal currents.

8.2.1.4 In determining the current-carrying capacity of bare conductors, account shall be taken of the arrangement made for their expansion and contraction, their joints, and the physical limitations of the metal of which they are made.

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*Specification for paper insulated lead-sheathed cables for electricity supply (*second revision*).

†Specification for factory-built assemblies of switchgear and controlgear for voltages up to and including 1 000 V ac and 1 200 V dc: Part 1 General requirements.

*Specification for factory-built assemblies of switchgear and controlgear for voltages up to and including 1 000 V ac and 1 200 V dc: Part 1 General requirements.

NOTE — It is recommended that the maximum operating temperature of bare conductors should not exceed 90°C.

8.2.1.5 Where cables are to be connected to bare conductors or busbars it shall be verified that their type of insulation and/or sheath is suitable for the maximum operating temperature of the bare conductors or busbars. Alternatively the insulation and/or sheath of the cables shall be removed for a distance of 150 mm from the connection and replace if necessary by suitable heat-resisting insulation.

8.2.1.6 Where a cable is to be run for a significant length in a space to which thermal insulation is likely to be applied, the cable shall, wherever practicable, be fixed in a position such that it will not be covered by the thermal insulation. Where fixing in such a position is impracticable, the current-carrying capacity of the cable shall be appropriately reduced.

NOTE — For a cable installed in thermally insulating wall or above a thermally insulated ceiling, the cable being in contact with a thermally conductive surface on one side, the rating factor to be applied may, in the absence of more precise information, be taken as 0·75 times the current-carrying capacity for that cable clipped direct to a surface and open. For a cable likely to be totally surrounded by thermally insulating material, the applicable rating factor may be as low as 0·5.

8.2.1.7 Metallic sheaths and/or non-magnetic armour of all single-core cables in the same circuit shall normally be bonded together at both ends of their run (solid bonding). Alternatively, where specified, such cables having conductors of cross-sectional area exceeding 50 mm^2 may be bonded together at one point in their run (single point bonding) with suitable insulation at the open-circuit end, in which case the length of the cables from the bonding point shall be limited so that voltages from sheaths and/or armour to Earth do not:

- exceed 25 volts and do not cause corrosion when the cables are carrying their full load current, and
- do not cause danger or damage to property when the cables are carrying short-circuit current.

8.2.2 *Voltage Drop* — The size of every bare conductor or cable conductor shall be such that the voltage drop within the installation does not exceed a value appropriate to the safe functioning of the associated equipment in normal service. Where an allowance is made for diversity in accordance with **3.1.2**, this may be taken into account in calculating voltage drop.

NOTE — In some instances a conductor larger than that permissible under **8.2.2** may be necessary for satisfactory starting of motors. Account should be taken of the effects of motor starting current on other equipment.

8.2.3 *Minimum Cross-Sectional Area of Neutral Conductors* — For polyphase circuits in which imbalance may occur in normal service, through significant inequality of loading or of power factors in the various phases, or through the presence of significant harmonic currents in the various phases, the neutral conductor shall have a cross-sectional area adequate to afford compliance with **8.2.1.1** for the maximum current likely to flow in it.

For polyphase circuits in which serious imbalance is unlikely to be sustained in normal service, other than discharge lighting circuits, the use of multicore cables incorporating a reduced neutral conductor in accordance with the appropriate Indian Standard is recognised. Where single-core cables are used in such circuits, the neutral conductor may have a reduced cross-sectional area appropriate to the expected value o the neutral current.

In any circuit where load is predominantly due to discharge lighting, the neutral conductor shal have a cross-sectional area not less than that o the phase conductor(s).

8.2.4 *Electromechanical Stresses* — All conductor and cables shall have adequate strength and be s installed as to withstand the electromechanica forces that may be caused by any current the may have to carry in service, including short-circuit current.

8.3 Environmental Conditions

8.3.1 *Ambient Temperature*

8.3.1.1 The type and current-carrying capacity of every conductor, cable and flexible cord termination and joint shall be selected so as to b suitable for the highest operating temperatur likely to occur in normal service, account bein taken of any transfer of heat from any accessory appliance or luminaire to which the conductor cable or flexible cord is connected.

8.3.1.2 Parts of a cable or flexible cord within an accessory, appliance or luminaire shall b suitable for the temperatures likely to be encountered, or shall be provided with additional insulation suitable for those temperatures. Such additional insulation shall be fitted over the individua cores of the cable of flexible cord in such a wa that the normal insulation of the cores is no relied upon to prevent a short circuit betwee conductors for an earth fault.

NOTE — Exposure of plastics-insulated cables high temperature, even for short periods, may cau the insulation to soften. Continuous exposure of PV compounds to temperatures above 115°C may contribut to the formation of corrosive products which can attac conductors and other metal-work.

8.3.1.3 In determining the normal operational conditions of conductors and cable, account need not be taken of the minimum ambient temperature likely to occur. However, precautions shall be taken to avoid risk of mechanical damage to cables susceptible to low temperatures.

8.3.1.4 The enclosures of wiring systems for conductors and cables shall be selected and installed so that they are suitable for the extremes of ambient temperature to which they are likely to be exposed in normal service. If a non-metallic or composite outlet box is used for the suspension of, or is in contact with, a luminaire and where a thermoplastic material (for example PVC) is the principal load-bearing member, care shall be taken that the temperature of the box does not exceed 60°C and that the mass suspended from the box does not exceed 3 kg.

NOTE — In determining the ambient temperature of such enclosures, account should be taken of the maximum normal operating temperatures of the conductors of cables installed within them.

8.3.1.5 In every vertical channel, duct, ducting or trunking containing conductors or cables, internal barriers shall be provided so as to prevent the air at the top of the channel, duct, ducting or trunking from attaining an excessively high temperature. The distance between barriers shall be the distance between floors or 5 m whichever is less.

NOTE — The fire barriers specified in **8.8.1** may serve also for compliance with **8.3.1.5**.

8.3.2 *Presence of Water or Moisture*

8.3.2.1 Every wiring system shall either be installed where it will not be exposed to rain, dripping water, steam, condensed water or accumulations of water or be of a type designed to withstand such exposure.

8.3.2.2 In damp situations and wherever they are exposed to the weather, all metal sheaths and armour of cables, metal conduit, ducts, ducting, trunking, clips and their fixings, shall be of corrosion-resisting material or finish and shall not be placed in contact with other metals with which they are liable to set up electrolytic action.

8.3.2.3 Copper-clad aluminium conductors shall not be used in situations where the termination of the conductors are likely to be exposed to sustained wet conditions.

NOTE — **8.3.2.2** and **8.3.2.3** do not apply to situation which may be only initially damp during building construction.

8.3.2.4 A plain aluminium conductor shall not be placed in contact with a terminal of brass or other metal having a high copper content, unless the terminal is suitably plated or other precautions are taken to maintain electrical continuity.

8.3.2.5 In any situation, the exposed conductor and insulation at terminations and joints of cables insulated with impregnated paper shall be protected from ingress of moisture by being suitably sealed.

8.3.2.6 The ends of mineral-insulated cables shall be protected from moisture by being suitably sealed and the insulation shall be thoroughly dry before the sealing material is applied. Such sealing material, and any material used to insulate the conductors where they emerge from the insulation, shall have adequate insulating and moisture-proofing properties, and shall retain those properties throughout the range of temperatures to which they may be subjected in service.

8.3.2.7 In damp situations, enclosures for cores of sheathed cables from which the sheath has been removed and for non-sheathed cables at terminations of conduit, duct, ducting or trunking systems shall be damp-proof and corrosion-resistant. Every joint in a cable shall be suitably protected against the effects of moisture.

8.3.2.8 Conduit systems not designed to be sealed shall be provided with drainage outlets at any points in the installation where moisture might otherwise collect.

8.3.2.9 Every entry to finished ducts, ducting or trunking shall be placed so as to prevent the ingress of water, or be protected against such ingress.

8.3.3 *Dust* — Enclosures for conductors and their joints and terminations in onerous dust conditions shall have the degree of protection IP 5X.

8.3.4 *Corrosive or Polluting Substances*

8.3.4.1 All metalwork of wiring systems shall either be installed where it will not be exposed to corrosive substances, or be of a type or be protected so as to withstand such exposure. Non-metallic materials of wiring systems shall not be placed in contact with materials likely to cause chemical deterioration of the wiring systems. Such materials shall either be installed where they will not be exposed to contact with oil, creosote, and similar hydrocarbons, or be of a type designed to withstand such exposure.

8.3.4.2 Soldering fluxes which remain acidic or corrosive at the completion of the soldering process shall not be used.

8.3.5 *Mechanical Stresses*

8.3.5.1 All conductors and cables shall be adequately protected against any risk of mechanical damage to which they may be liable in normal conditions of service.

8.3.5.2 Where cables are installed under floors or above ceilings they shall be run in such positions that they are not liable to be damaged by contact with the floor or the ceiling or their fixings. Where the cable passes through a timber joint within a floor or ceiling construction (for example, under floorboards), the cable shall be 50 mm, measured vertically, from the top or bottom, as appropriate, of the joist. Alternatively, cables not protected by an earthed metallic sheath shall be protected by enclosure in earthed steel conduit securely supported, or by equivalent mechanical protection sufficient to prevent penetration of the cable by nails, screws, and the like.

8.3.5.3 Where cables pass through holes in metalwork, precautions shall be taken to prevent abrasion of the cables on any sharp edges.

8.3.5.4 Non-sheathed cables for fixed wiring shall be enclosed in conduit, duct, ducting or trunking. Such non-sheathed cables shall not be installed in ducts cast *in-situ* in concrete where any part of the completed duct is formed by the concrete or screed.

8.3.5.5 Cables buried direct in the ground shall be of a type incorporating an armour or metal sheath or both, or be of the PVC, insulated concentric type. Such cables shall be marked by cable covers or a suitable marking tape and be buried at a sufficient depth to avoid their being damaged by any disturbance of the ground reasonably likely to occur during the normal use of the premises.

8.3.5.6 Cables to be installed in underground ducts or pipes shall be of a type incorporating a sheath and/or armour suitably resistant to any mechanical damage likely to be caused during drawing-in.

8.3.5.7 Cables to be installed outdoors on walls and the like shall incorporate a sheath and/or armour suitably resistant to any mechanical damage likely to occur, or be contained in a conduit system or other enclosure affording adequate protection against such damage.

8.3.5.8 Cables for overhead wiring between a building and a point of utilisation not attached thereto (for example, another building) shall be so placed and at such a height as to be out of reach of any sources of mechanical damage reasonably to be foreseen in the normal use of the premises. Alternatively for spans in situations inaccessible to vehicular traffic, such cables may be installed in conduit or other enclosure affording adequate protection against such damage.

NOTE 1 — Bare or lightly insulated overhead conductors are required to be placed out of reach of persons and livestock, for compliance with **5.1.2.4**.

NOTE 2 — *See* Appendix B for notes on methods of support.

8.3.5.9 Flexible cords, where they are exposed to risk of mechanical damage, shall be of a type sheathed with rubber or PVC, and where necessary, shall also be armoured; provided that for domestic and similar applications where flexible cords are subject only to moderate bending and/or wear, unkinkable flexible cords may be used.

8.3.5.10 Braided circular twin and three-core flexible cords insulated with glass fibre shall be used only for luminaires or for other applications where the cord is not subject to abrasion or undue flexing.

8.3.5.11 Flexible cords shall not be used as fixed wiring, except as permitted by **8.3.5.13**, unless contained in an enclosure affording mechanical protection.

8.3.5.12 Flexible cables or flexible cords shall be used for connections to portable equipment. For the purpose of this clause an electric appliance of rated input exceeding 3 kW is cosidered not to be portable. Such flexible cables or flexible cords shall be of suitable length to avoid undue risk of mechanical damage.

8.3.5.13 Exposed lengths of flexible cable or flexible cord used for final connections to fixed equipment shall be as short as possible and connected to the fixed wiring by a suitable accessory or an enclosure, by a suitable device or devices for overcurrent protection, isolation, and switching.

8.3.5.14 Where a flexible cord supports or partly supports a luminaire, the maximum mass supported by the cord shall not exceed the appropriate value indicated below:

Nominal Cross-Sectional Area of Conductor (mm²)	*Maximum Mass* (kg)
0·5	2
0·75	3
1·0	5
1·5	5·3
2·5	8·8
4	14·0

8.3.5.15 In assessing risks of mechanical damage to cables, account shall be taken of any mechanical strains likely to be imposed during the normal process of erection of the cables.

8.3.6 *Damage by Fauna* — In premises intended for livestock, all fixed wiring systems shall be inaccessible to livestock. Cables liable to attack by vermin shall be of a suitable type or be suitably protected.

8.3.7 *Solar Radiation*— Cables and wiring systems installed in positions which may be exposed to direct sunlight shall be of a type resistant to damage by ultra-violet light.

8.4 Identification

8.4.1 Reference is drawn to IS : 11353-1986* on marking of conductors and apparatus terminals by colours and alphanumeric code.

8.5 Prevention of Mutual Detrimental Influence

8.5.1 *Between Low Voltage Circuits and Circuits of Other Categories*

8.5.1.1 Low voltage circuits shall be segregated from extra-low voltage circuits.

8.5.1.2 Where an installation comprises circuits for telecommunication, fire-alarm or emergency lighting systems, as well as circuits operating at low voltage and connected directly to a mains supply system, precautions shall be taken, in accordance with clauses below, to prevent electrical contact (and for fire-alarm circuits and emergency lighting circuits, physical contact) between the cables of the various types of circuit.

NOTE 1 — *See* the definition in Section 1 for 'circuit' which gives details of the three categories used in clauses below.

NOTE 2 — Where it is proposed to instal cables of category 1 circuits in the same cable enclosure or duct as cables of a telecommunication system which may be connected to lines provided by a public telecommunication system authority, the approval of that authority is necessary.

NOTE 3 — Cables used to connect the battery chargers of self-contained luminaires to the normal mains circuit are not considered to be emergency lighting circuits.

8.5.1.3 Cables of category 1 circuits shall not be drawn into the same conduit, duct or ducting as cables of category 2 circuits, unless the latter cables are insulated in accordance with the requirements of these clauses for the highest voltage present in the category 1 circuits.

8.5.1.4 Cables of category 1 circuits shall not in any circumstances be drawn into the same conduit, duct or ducting as cables of category 3 circuits.

8.5.1.5 Where a common channel or trunking is used to contain cables of category 1 and category 2 circuits, all cables connected to category 1 circuits shall be effectively partitioned from the cables of the category 2 circuits or alternatively the latter cables shall be insulated in accordance with the requirements of these clauses for the highest voltage present in the category 1 circuits (*see also* **8.5.1.7**).

8.5.1.6 Where category 3 circuits are installed in a channel or trunking containing circuits of any other category, these circuits shall be segregated from the latter by continuous partitions such that the specified integrity of the category 3 circuits is not reduced. These partitions shall also be provided at any common outlets in a trunking system accommodating category 3 circuits and circuits of other categories. Where mineral-insulated cables are used for category 3 circuits such partitions are not normally required. Where partitions are not used, the mineral-insulated cables shall be rated for exposed-to-touch conditions.

8.5.1.7 In conduit, duct, ducting or trunking systems, controls or outlets for category 1 and category 2 circuits shall not be mounted in or on common boxes, switchplates or blocks. Where it becomes unavoidable the cables and connections of the two categories of circuit shall be partitioned by means of rigidly fixed screens or barriers.

8.5.1.8 Where cores of category 1 and category 2 circuits are contained in a common multicore cable, flexible cable or flexible cord, the cores of the category 2 circuits shall be insulated individually or collectively as a group, in accordance with the requirements of these clauses, for the highest voltage present in the category 1 circuits, or alternatively, shall be separated from the cores of the category 1 circuits by an earthed metal braid of equivalent current-carrying capacity to that of the cores of the category 1 circuits. Where terminations of the two categories of circuit are mounted in or on common boxes, switchplates or blocks, they shall be partitioned in accordance with **8.5.1.7** or alternatively be mounted on separate and distinct terminal blocks adequately marked to indicate their function.

8.5.1.9 Cores of category 1 and category 3 circuits shall not in any circumstances be contained in a common multicore cable, flexible cable or flexible cord.

8.5.2 *Between Electrical Services and Exposed Metalwork of Other Services*

8.5.2.1 Metal sheaths and armour of all cables operating at low voltage, and metal conduits, ducts, ducting and trunking and bare protective conductors associated with such cables, which might otherwise come into fortuitous contact with other fixed metalwork shall be either effectually segregated therefrom, or effectually bonded thereto. (Reference is also invited to IS : 3043-1987*).

8.5.2.2 Electrical services shall not be installed in the same conduit, ducting or trunking as pipes or tubes of non-electrical services, for example air, gas, oil or water.

8.5.2.3 No cables other than those which form part of lift installation and its supply feeder shall be run in a lift (or hoist) shaft.

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*Guide for uniform system of marking and identification of conductors and apparatus terminals.

*Code of practice for earthing (*first revision*).

8.6 Accessibility

8.6.1 Joints in non-flexible cables and joints between non-flexible and flexible cables or cords shall be accessible for inspection. However, this requirement shall not apply to joints:

a) in cable buried underground,
b) enclosed in building materials, and
c) made by welding, soldering, brazing or compression and contained within an enclosure (such as a box).

The joints mentioned in item (b), if inexcessible shall not be made by means of mechanical clamps.

8.6.2 Inspection-type conduit fittings shall be so installed that they can remain accessible for such purposes as the withdrawal of existing cables or the installing of additional cables.

8.7 Joints and Terminations

8.7.1 Every connection at a cable termination or joint shall be mechanically and electrically sound, be protected against mechanical damage and any vibration liable to occur, shall not impose any appreciable mechanical strain on the fixing of the connection, and shall not cause any harmful mechanical damage to the cable conductor. Joints in non-flexible cables shall be made by soldering, brazing, welding, or mechanical clamps, or be of the compression type. All mechanical clamps and compression-type sockets shall securely retain all the wires of the conductor.

8.7.2 Terminations and joints shall be appropriate to the size and type of conductor with which they are to be used.

8.7.3 Terminations and joints shall be suitably insulated for the voltage of the circuits in which they are situated.

8.7.4 Where a termination or joint in an insulated conductor, other than a protective conductor is not made in an accessory or luminaire complying with the appropriate Indian Standard, it shall be enclosed in material requisite qualities. Such an enclosure may be formed by part of an accessory or luminaire and a part of the building structure.

8.7.5 Cores of sheathed cables from which the sheath has been removed and non-sheathed cables at the terminations of conduit, ducting or trunking shall be enclosed as specified above. Alternatively the enclosure may be a box complying with appropriate Indian Standard.

8.7.6 Terminations of mineral-insulated cables shall be provided with sleeves having a temperature rating similar to that of the seals.

8.7.7 Cable glands shall securely retain without damage the outer sheath or armour of the cables.

8.7.8 Appropriate cable coupers shall be used for connecting together lengths of flexible cable or flexible cord.

8.7.9 Ends of lengths of conduit shall be free from burrs, and where they terminate at boxes, trunking and accessories not fitted with spout entries, shall be treated so as to obviate damage to cables.

8.7.10 Substantial boxes of ample capacity shall be provided at every junction involving a cable connection in a conduit system.

8.7.11 Every outlet for cables from a duct system or ducting system, every joint in such a system, and every joint between such a system and another type of duct, ducting, or conduit, shall be formed so that the joints are mechanically sound and that the cables drawn in are not liable to suffer damage.

8.8 Fire Barriers — Where cables, conduits, ducts, ducting or trunking pass through fire-resistant structural elements such as floors and walls designated as fire barriers, the opening made shall be sealed according to the appropriate degree of fire resistance. In addition, where cables, conduits or conductors are installed in channels, ducts, ducting, trunking or shafts which pass through such elements, suitable internal fire-resistant barriers shall be provided to prevent the spread of fire.

8.9 Supports, Bends and Space Factors

8.9.1 *Supports*

8.9.1.1 Every cable and conductor used as fixed wiring shall be supported in such a way that it is not exposed to undue mechanical strain and so that there is no appreciable mechanical strain on the terminations of the conductors, account being taken of mechanical strain imposed by the supported mass of the cable or conductor itself.

8.9.1.2 All conduit, ducting and trunking shall be properly supported and of a type suitable for any risk of mechanical damage to which they may be liable in normal conditions of service or adequately protected against such damage.

8.9.2 *Bends*

8.9.2.1 The internal radius of every bend in a non-flexible cable such as not to cause damage to the cable.

8.9.2.2 The use of solid (non-inspection) conduit elbows or tees shall be restricted to:

- locations at the ends of conduits immediately behind a luminaire, outlet box or conduit fitting of the inspection type; and
- one solid elbow located at a position not more than 500 mm from a readily accessible outlet box in a conduit run not exceeding 10 m between two outlet points

provided that all other bends on the conduit run are not more than the equivalent of one right angle.

8.9.2.3 The radius of every conduit bend shall be such as to allow compliance with **8.9.2.1** for bends in cables and, in any event, the inner radius of the bend shall be not less than 2·5 times the outside diameter of the conduit.

8.9.2.4 Every bend in a closed duct or ducting shall be of an inner radius allowing compliance with **8.9.2.1**.

8.9.3 *Space Factors* — The number of cable drawn into, or laid in, an enclosure of a wiring system shall be such that no damage is caused to the cable or to the enclosure during their installation.

9. SWITCHGEAR

9.0 Common Requirements

9.0.1 Where an item of switchgear is required by this code to disconnect all live conductors of a circuit, it shall be of a type such that the neutral conductor cannot be disconnected before the phase conductors and is reconnected at the same time as or before the phase conductors.

9.0.2 Single-pole switchgear shall not be connected in the neutral conductor of TN or TT systems.

9.0.3 Every fuse and circuit breaker shall be selected for a voltage not less than the maximum voltage difference (rms value, for ac) which normally develops under fault conditions.

9.1 Devices for Protection Against Electric Shock (*see also* Section 3 of IS : 3043-1987*)

9.1.1 *Overcurrent Protective Devices*

9.1.1.1 For TN and TT systems, every overcurrent protective device which is to be used also for protection against electric shock (indirect contact) shall be selected so that its operating time is:

a) appropriate to the value of fault current that would flow in the event of a fault of negligible impedance between a phase conductor and exposed conductive parts, so that the permissible final temperature of the related protective conductor is not exceeded; and

b) appropriate to compliance with the requirements of **5.1.3.1**(a)(iii).

Note — The operating time of an overcurrent protective device used in this way depends upon the value of the fault loop impedance which, in TT system may be liable to considerable change with time, for example with seasonal variations. In the absence of reliable information in this respect protection against electric shock in TT systems is preferably to be provided by means other than the overcurrent protective devices. The use of residual current devices is a preferred alternative.

9.1.1.2 For TT systems, where exposed conductive parts are connected together and overcurrent protective devices are to be used to provide protection against electric shock in the event of a second fault, the requirements for the protective devices are similar to those for TN systems as specified in **9.1.1.1**.

9.1.1.3 The overcurrent protective devices shall conform to the relevant Indian Standards.

9.1.1.4 When semi-enclosed fuse units are used for overcurrent protection, the nominal current rating of the circuit being protected to be indicated adjacent to the fuse.

9.1.2 *Residual Current Devices*

9.1.2.1 Residual current devices shall be capable of disconnecting all the phase conductors of the circuit.

9.1.2.2 The residual operating current of the protective device shall comply with the requirements of **5.1.3.1**(a)(v) as appropriate to the type of system earthing (*see* IS : 3043-1987*). Where the characteristics of the current-using equipment to be supplied can be determined, it shall be verified that the vectorial sum of the leakage currents on the part of the installation situated on the load side of the device; and the vectorial sum of the leakage currents in normal service of the various items of equipment supplied by that part of the installation shall be less than one half the nominal residual operating current of the device. For TT and IT systems, allowance shall be made for any likely variation of earthing resistance with time, for example, with seasonal variations.

Note — For large installation, sub-division of the earthing arrangements is likely to be necessary because of the magnitude of the total inherent leakage of the cables and other equipment.

9.1.2.3 Where operation of a residual current device relies upon a separate auxiliary supply external to the device, then either:

a) the device shall be of a type that will operate automatically in case of failure of the auxiliary supply, or

b) the device shall incorporate, or be provided with, a supply which shall be available automatically upon failure of the auxiliary supply.

9.1.2.4 Residual current device shall be located outside the magnetic field of other equipment, unless it is verified that their operation will not be impaired thereby.

9.1.2.5 Where a residual current device for protection against indirect contact is used with, but separately from, overcurrent protective devices, it shall be verified that the residual current operated device is capable of withstanding, without damage, the thermal and mechanical stresses

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*Code of practice for earthing (*first revision*).

*Code of practice for earthing (*first revision*).

to which it is likely to be subjected in case of a short circuit occurring on the load side of the point at which it is installed.

NOTE — The stresses mentioned here depend upon the prospective short-circuit current at the point where the residual current device is installed, and the operating characteristics of the device providing short-circuit protection.

9.2 Insulation Monitoring Devices — Under consideration.

9.3 Devices for Protection Against Overvoltage/Undervoltage and Coordination Between Various Devices — Under consideration.

9.4 Isolating and Switching Devices

9.4.1 *General* — Isolating and switching devices shall comply with the appropriate requirements of the following clauses. A common device may be used for more than one of these functions if the appropriate requirements for each function are met.

9.4.2 *Devices for Isolation*

9.4.2.1 Devices for isolation shall effectively disconnect all live supply conductors from the circuit concerned.

9.4.2.2 The isolating distances between contacts or other means of isolation when in open position shall be not less than those specified for isolators.

9.4.2.3 Semiconductor devices shall not be used as isolators.

9.4.2.4 The position of the contacts or other means of isolation shall be either externally visible or clearly and reliably indicated. An indication of the isolated position shall occur only when the specified isolating distance has been attained in each pole.

9.4.2.5 Devices for isolation shall be selected and/or installed in such a way as to prevent unintentional reclosure.

NOTE — Such reclosure might be caused, for example, by mechanical shock and vibration.

Provision shall be made for securing off-load devices for isolation against inadvertent and unauthorised operation.

NOTE — This provision may be achieved by locating the off-load device in a lockable space or enclosure accessible only to skilled persons, or by padlocking. Alternatively, the off-load device may be interlocked with a load-breaking device.

9.4.2.6 Isolation shall be achieved preferably by the use of a multipole device cutting off all poles of the supply or, alternatively, by the use of single-pole devices which are situated adjacent to each other. This requirement does not apply to neutral links in TN-S systems.

9.4.3 *Devices for Switching Off for Mechanical Maintenance*

9.4.3.1 Devices for switching off for mechanical maintenance shall be inserted where practicable in the main supply circuit. Alternatively, such devices may be inserted in the control circuit provided that supplementary precautions are taken to provide a degree of safety equivalent to that of interruption of the main supply, for example where such an arrangement is specified in the appropriate Indian Standard.

9.4.3.2 Devices for switching off for mechanical maintenance of or control switches for such devices shall be manually initiated and shall have an externally visible contact gap or a clearly and reliably indicated OFF or OPEN position. Indication of that position shall occur only when the OFF or OPEN position on each pole has been attained.

9.4.3.3 Devices for switching off for mechanical maintenance shall be selected and/or installed in such a way as to prevent unintentional reclosure.

NOTE — Such reclosure might be caused, for example, by mechanical shock and vibration.

9.4.3.4 Where switches are used as devices for switching off for mechanical maintenance, they shall be capable of cutting off the full load current of the relevant part of the installation.

9.4.4 *Devices for Emergency Switching*

9.4.4.1 Means of interrupting the supply for the purpose of emergency shall be capable of cutting off the full load current of the relevant part of the installation. Where appropriate, due account shall be taken of stalled motor conditions.

9.4.4.2 Means for emergency switching shall consist of:

- a single switching device directly cutting off the incoming supply, or
- a combination of several items of equipment operated by one initiation only and resulting in the removal of the hazard by cutting off the appropriate supply; emergency stopping may include the retention of supply for electric breaking facilities.

Plugs and socket outlets shall not be used for emergency switching.

9.4.4.3 Devices for emergency switching shall be, where practicable, manually operated, directly interrupting the main circuit. Devices such as circuit-breakers and contractors operated by remote control shall open on de-energisation of the coils, or other techniques of suitable reliability shall be employed.

9.4.4.4 The operating means (such as handles and push buttons) for devices for emergency switching shall be clearly identifiable and preferably coloured red. They shall be installed in a readily accessible position where the hazard might occur and, where appropriate; at any additional remote position from which the device for emergency switching may need to be operated.

9.4.4.5 The operating means of the device for emergency switching shall be of the latching type or capable of being restrained in the OFF or STOP position. A device in which the operating means automatically reset is permitted where both the operating means and the means of re-energising are under the control of one and the same person. The release of the emergency switching device shall not re-energise the equipment concerned, unless an appropriate warning that the equipment may restart automatically is clearly indicated.

9.4.4.6 Every fireman's emergency switch provided for compliance with **5.6.3** shall:

a) be coloured red and have fixed on or near it a nameplate marked with the words 'FIREMAN'S SWITCH', the plate being the minimum size 150 × 100 mm, in lettering easily legible from a distance appropriate to the site conditions, but not less than 13 mm high;

b) have its ON and OFF positions clearly indicated by lettering legible to a person standing on the ground at the intended site, and the OFF position shall be at the top; and

c) preferably, be provided with a lock or catch to prevent the switch being inadvertently returned to the ON position.

NOTE — It is desirable that the nameplate mentioned in (a) above be marked also with the name of the company which installed or which maintains (if different) the installation concerned.

9.4.5 *Devices for Functional Switching*

9.4.5.1 Plugs and socket outlets of rating not exceeding 16 A may be used as switching devices but not for emergency switching (*see also* **9.4.4.2**). A plug and socket outlet of rating exceeding 16 A ac, may be used as a switching device (other than an emergency switching device) where the plug and socket outlet has a breaking capacity appropriate to the use intended. Plugs and socket outlets of rating exceeding 16 A shall not be used as switching devices for dc circuits.

9.4.5.2 Every switch for discharge lighting circuit shall be designed and marked for such purposes. Alternatively, it shall have a nominal current not less than twice the total steady current which it is required to carry or, if used to control both filament lighting and discharge lighting, shall have a nominal current not less than the sum of the current of the filament lamps and twice the total steady current of the discharge lamps.

10. EARTHING ARRANGEMENT AND PROTECTIVE CONDUCTORS (*see* IS : 3043-1987*)

11. SUPPLIES FOR SAFETY SERVICES

11.1 General

11.1.1 For safety services, a source of supply shall be selected which will maintain a supply for adequate duration.

11.1.2 For safety services required to operate in fire conditions, all equipment shall be provided, either by construction or by erection, with protection providing fire resistance of adequate duration.

11.1.3 Protective measures against indirect contact without automatic disconnection at the first fault are preferred. In IT systems, continuous insulation monitoring devices shall be provided which give an audible and visible indication of a first fault.

11.2 Sources

NOTE — Starter-type batteries for vehicles will generally not fulfil the requirements for sources for safety services.

11.2.1 Sources for safety services shall be installed as fixed equipment and in such a manner that they cannot be adversely affected by failure of the normal source.

11.2.2 Sources for safety services shall be placed in a suitable location and be accessible only to skilled or instructed persons.

11.2.3 A single source for safety services shall not be used for other purposes. However, where more than one source is available, such sources may supply standby systems provided that, in the event of failure of one source, the energy remaining available will be sufficient for the starting and operation of all safety services; this generally necessitates the automatic off-loading of equipment not providing safety services.

11.2.4 Clauses **11.2.1** to **11.2.3** do not apply to equipment individually supplied by self-contained batteries.

11.3 Circuits

11.3.1 Circuits of safety services shall be independent of other circuit.

NOTE — This means that an electrical fault or any intervention or modification in one system will not affect the correct functioning of the other. This may necessitate separation by fire-resistant materials or use of different routes or enclosures.

11.3.2 Circuits of safety services shall not pass through locations exposed to fire risk unless the wiring systems used are fire resistant.

NOTE — Where practicable the passage of circuits through locations presenting to a fire risk or explosion risk should be avoided.

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*Code of practice for earthing (*first revision*).

11.3.3 The protection against overload may be omitted.

11.3.4 Overcurrent protective device shall be selected and erected so as to avoid an overcurrent in one circuit imparing the correct operation of other circuits of safety services.

11.3.5 Switchgear and controlgear, except alarm devices, shall be clearly identified and grouped in locations accessible only to skilled or instructed persons. Alarm devices shall be clearly identified.

11.4 Utilisation Equipment — In equipment supplied by two different circuits, a fault occurring in one circuit shall not impair the protection against electric shock nor the correct operation of the other circuit. Such equipment shall be selected to the protective conductors of both circuits, if necessary.

11.5 Special Requirements for Safety Service Having Sources Not Capable of Operation in Parallel

11.5.1 Precautions shall be taken to prevent the paralleling of the sources, for example, by mechanical interlocking.

11.5.2 The requirements of these clauses for protection against short circuit and indirect contact shall be met for each source.

11.6 Special Requirements for Safety Services Having Sources Capable of Operation in Parallel

NOTE — *See also* 4.1.3.2.

11.6.1 The requirements of these clauses for protection against short circuit and against indirect contact shall be met whether the installation is supplied by either of the two sources or by both in parallel.

11.7 Specific Guidelines for Individual Equipment — For specific guidelines for individual equipment, fittings and accessories, reference is invited to Appendices C and D.

SECTION 5 INSPECTION AND TESTING

12. INITIAL INSPECTION AND TESTING

12.1 General

12.1.1 Every installation shall, on completion and before being energised, be inspected and tested in accordance with the requirements of this section to verify, as far as practicable, that the requirements of these clauses have been met.

The methods of test shall be such that no danger to persons or property or damage to equipment can occur even if the circuit tested is defective.

12.2 Visual Inspection

12.2.1 A visual inspection shall be made to verify that the installed electrical equipment is:

- in compliance with the applicable Indian Standards (this may be ascertained by mark or by certification furnished by the installer or by the manufacturer),
- correctly selected and erected in accordance with this code, and
- not visibly damaged so as to impair safety.

NOTE — Appendix E lists the principal features of an installation to be visually inspected in order to verify compliance with this code.

12.3 Testing

12.3.1 *General* — The following items, where relevant, shall be tested in the sequence indicated. Standard methods of testing, in respect of some of the following clauses of this section, are given in Appendix C, the use of other methods is not precluded provided that they give no less effective results:

a) Continuity of ring final circuit conductors,
b) Continuity of protective conductors, including main and supplementary equipotential bonding,
c) Earth electrode resistance,
d) Insulation resistance,
e) Insulation of site-built assemblies,
f) Protection by electrical separation,
g) Protection by barriers or enclosures provided during erection,
h) Insulation of non-conducting floors and walls,
j) Polarity,
k) Earth fault loop impedance,
m) Operation of residual current devices and fault-voltage operated protective devices.

In the event of any test indicating failure to comply, that test and those preceding, the results of which may have been influenced by the fault indicated, shall be repeated after the fault has been rectified.

12.3.2 *Continuity of Ring Final Circuit Conductors* — A test shall be made to verify the continuity of all conductors (including the protective conductor) of every ring final circuit.

12.3.3 *Continuity of Protective Conductor* — Every protective conductor shall be separately tested to verify that it is electrically sound and correctly connected. This test shall include all conductors and any extraneous conductive parts used for equipotential bonding.

12.3.4 *Earth Electrode Resistance* — Where it is necessary to measure the resistance of an earth electrode, the test method described in IS : 3043-1987* shall be used.

12.3.5 *Insulation Resistance*

12.3.5.1 The tests described below shall be made before the installation is permanently connected to the supply. For these tests large installations may be divided into groups of outlets, each containing not less than 50 outlets. For the purposes of this code the term 'outlet' includes every point and every switch except that a socket outlet, appliance or luminaire incorporating a switch is regarded as one outlet. The test voltage for insulation resistance measurement shall be:

for extra low voltage circuits — Up to 250-500 V

for 250-500 V circuits — 1 000 V

for circuits above 500 V — 2·5 kV

12.3.5.2 When measured with all fuse links in place, all switches (including, if practicable, the main switch) closed and, except for TN-C systems, all poles or phases of the wiring electrically connected together, the insulation resistance to earth shall be not less than 1 megohm.

12.3.5.3 When measured between all the conductors connected to any one phase or pole of the supply and, in turn, all conductors connected to each other phase or pole, the insulation resistance shall be not less than 1 megohm. Wherever practicable, so that all parts of the wiring may be tested, all lamps shall be removed and all current-using equipment shall be disconnected and all local switches controlling such lamps or other equipment shall be closed. Where the removal of lamps and/or the disconnection of current-using equipment is impracticable, the local switches controlling such lamps and/or equipment shall be open. Particular attention shall be given to the presence of electronic devices connected in the installation and such devices shall be isolated so that they are not damaged by the test voltage.

12.3.5.4 Where equipment is disconnected for the tests prescribed above, and the equipment has exposed conductive parts required by these clauses to be connected to protective conductors, the insulation resistance between the exposed conductive parts and all live parts of the equipment shall be measured separately and shall comply with the requirements of the appropriate Indian Standard the insulation resistance shall be not less than 0·5 megohm.

12.3.6 *Insulation of Site-Built Assemblies*

12.3.6.1 Where protection against direct contact is intended to be afforded by insulation applied to live parts during erection in accordance with **5.1.2.1** (a), it shall be verified that the insulation is capable of withstanding, without breakdown or flashover, an applied test voltage equivalent to that specified in the Indian Standard for similar factory-built equipment.

12.3.6.2 Where protection against indirect contact is provided by supplementary insulation applied to equipment during erection in accordance with **5.1.3.2**, it shall be verified by test:

- that the insulating enclosure affords a degree of protection not less than IP2X, and
- that the insulating enclosure is capable of withstanding, without breakdown or flashover, an applied test voltage equivalent to that specified in the Indian Standard for similar factory built-equipment.

12.3.7 *Electrical Separation of Circuits* — Where protection against electric shock is provided by safety extra-low voltage or by electrical separation, the electrical separation of the separated circuits shall be inspected and/or tested.

Where the source of the separated circuit is other than a safety isolating transformer or a source independent of a higher voltage circuit, it shall be verified that the source provides a degree of safety equivalent to that of a safety isolating transformer, if necessary by performing the applicable tests of insulation resistance and electric strength.

It shall also be verified that the live parts of equipment of the separated circuit, other than cables, have a degree of electrical separation from other circuits not less than that between the input and output windings of a safety isolating transformer, if necessary by performing the applicable tests of insulation resistance and electric strength.

12.3.8 *Protection Against Direct Contact by Barriers or Enclosures Provided During Erection* — Where protection against direct contact is intended to be afforded by barriers or enclosures provided during erection in accordance with **5.1.2.2**, it shall be verified by test that the enclosures or barriers afford a degree of protection not less than IP2X or IP4X as appropriate.

12.3.9 *Insulation of Non-conducting Floors and Walls* — Where protection against indirect contact is to be provided by a non-conducting location the resistance of the floors and walls of the location to the main protective conductor of the installation shall be measured at not less than three points on each relevant surface one of which shall be not less than 1 m and not more than 1·2 m from any extraneous conductive parts, it

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*Code of practice for earthing (*first revision*).

shall be able to withstand a test voltage of at least 2 kV, and shall not pass a leakage current exceeding 1 mA in normal conditions of use.

12.3.10 *Polarity* — A test of polarity shall be made and it shall be verified that all fuses and single-pole control devices are connected in the phase conductor only, that centre-contact bayonet and Edison-type screw lampholders in circuits having an earthed neutral conductor, have their outer or screwed contacts connected to that conductor, and that wiring has been correctly connected to socket outlets.

12.3.11 *Earth Fault Loop Impedance* — Where protective measures are used which require a knowledge of earth fault loop impedance, the relevant impedance shall be measured, or determined by an equally effective method.

12.3.12 *Operation of Residual Current Operated and Fault-Voltage Operated Protective Devices* — Where protection against indirect contact is to be provided by a residual current device or a fault-voltage operated protective device, its effectiveness shall be verified by a test simulating an appropriate fault condition and independent of any test facility incorporated in the device.

13. ALTERATIONS TO INSTALLATIONS

13.1 In case of an alteration to an existing installation, it shall be verified that the installation after the alteration complies with this code and does not impair the safety of the existing installation.

APPENDIX A

(*Clause* 8.1.7.1)

TYPES OF WIRING SYSTEMS AND THEIR SELECTION

NOTE — Other types of wiring systems, not covered in this Appendix, may be used provided they comply with the general rules of this code.

A-1. The method of installation of a wiring system in relation to the type of conductor cable used shall be in accordance with Table 2.

A-2. The method of installation of a wiring system in relation to the situation concerned shall be in accordance with Table 3.

A-3. Examples of wiring systems are shown in Tables 2, 3 and 4.

TABLE 2 SELECTION OF WIRING SYSTEMS IN RELATION TO CONDUCTORS

(*Clause* A-3)

CONDUCTORS AND CABLES	METHOD OF INSTALLATION							
	Without Fixing	Clipped Direct	Conduit	Cable Trunking (Including Skirting Trunking, Flush Floor Trunking)	Cable Ducting	Cable Ladder, Cable Tray, Cable Brackets	On Insulators	Support Wire
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bare conductors	×	×	×	×	×	×	√	×
Insulated conductors	×	×	√	√	√	×	√	×
Sheathed cables (including armoured and mineral insulated)								
Multi-core	√	√	√	√	√	√	—	√
Single-core	—	√	√	√	√	√	—	√

Key

√ : Permitted

× : Not permitted

— : Not applicable, or not normally used in practice

TABLE 3 ERECTION OF WIRING SYSTEMS IN RELATION TO SITUATION

(*Clause* A-3)

Situations	Method of Installation							
	Without Fixing	Clipped Direct	Conduit	Cable Trunking (Including Skirting Trunking, Flush Floor Trunking)	Cable Ducting	Cable Ladder, Cable Tray, Cable Brackets	On Insulators	Support Wire
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Building voids	21, 25, 73, 74	—	22, 73, 74	×	23	12, 13, 14, 15, 16	×	×
Cable channel	43	43	41, 42	—	—	12, 13, 14, 15, 16	×	×
Embedded in ground	62, 63	—	61	×	61	—	×	×
Embedded in structure	52, 53	51	1, 2, 5	33	24	—	×	×
Surface mounted	×	11	3	31, 32, 71, 72	4	12, 13, 14, 15, 16	18	×
Overhead	×	×	—	34	×	12, 13, 14, 15, 16	18	17
Immersed	81	81	—	×	—	—	×	×

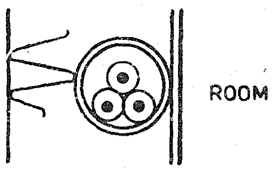
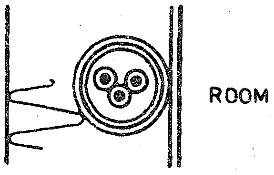
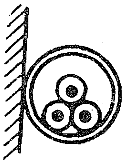
Key

Numbers : Permitted (Number refers to Table 4)
× : Not permitted
— : Not applicable or not normally used in practice.

TABLE 4 EXAMPLES OF WIRING SYSTEMS

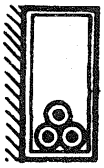
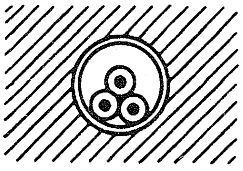
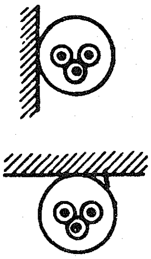
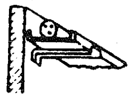
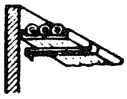
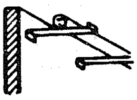
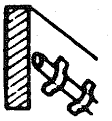
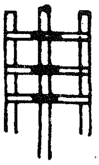
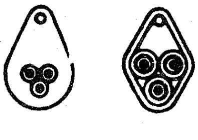
(*Clause* A-3)

Note — The illustrations are not intended to depict actual product or installation practice but are indicative of the method described.

Example	Description	Ref
	Insulated conductors in conduits in insulating walls	1
	Multicore cables in conduits in insulating walls	2
	Insulated conductors in conduits on a wall	3

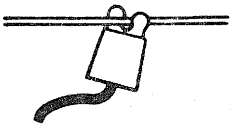
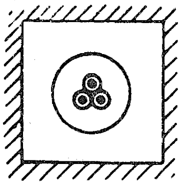
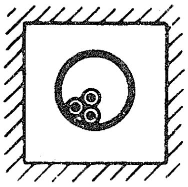
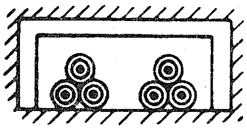
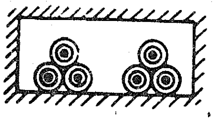
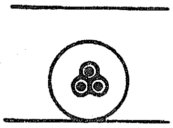
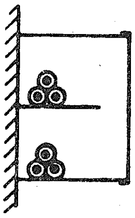
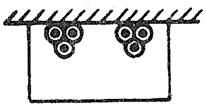
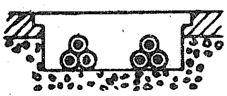
(*Continued*)

TABLE 4 EXAMPLES OF WIRING SYSTEMS — *Contd*

Example	Description	Ref
	Insulated conductors in cable ducting on a wall	4
	Insulated conductors in conduit in masonry	5
	Sheathed and/or armoured cables and mineral insulated cables on or spaced from a wall or ceiling	11
	On unperforated trays	12
	On perforated trays	13
	On brackets	14
	On cleats	15
	On ladder	16
	Sheathed single core or multicore cables suspended from or incorporating a support wire	17

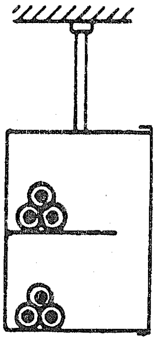
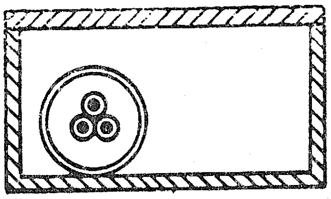
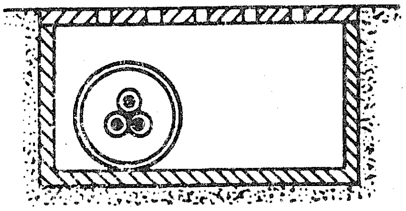
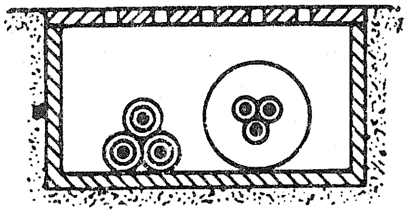
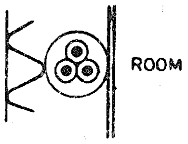
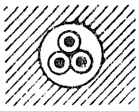
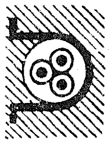
(*Continued*)

TABLE 4 EXAMPLES OF WIRING SYSTEMS – *Contd*

EXAMPLE	DESCRIPTION	REF
	Bare or insulated conductors on insulators	18
	Sheathed single core or multicore cables in building voids	21
	Insulated conductors in conduit in building voids	22
	Insulated conductors in cable ducting in building voids	23
	Insulated conductors in cable ducting in masonry	24
	Sheathed single core or multicore cables: a) in ceiling void, and b) in suspended floor	25
	Insulated conductors in cable trunking on a wall: a) Run horizontally	31
	b) Run vertically	32
	c) Insulated conductors in flush cable-trunking	33

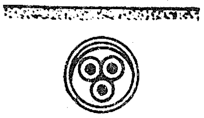
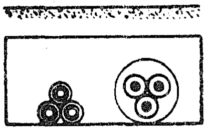
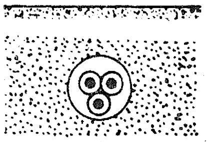
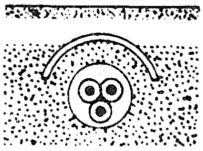
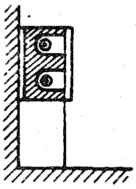
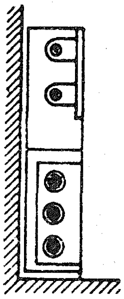
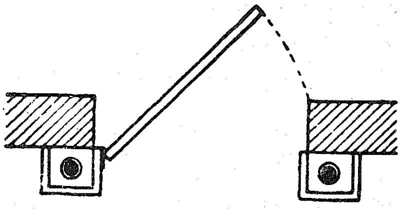
(*Continued*)

TABLE 4 EXAMPLES OF WIRING SYSTEMS — *Contd*

EXAMPLE	DESCRIPTION	REF
	d) Insulated conductors in suspended cable trunking	34
	e) Insulated conductors in conduits in enclosed cable channels, run horizontally or vertically	41
	f) Insulated conductors in conduits in ventilated cable channels in floor	42
	g) Sheathed single-core or multi-core cables in open or ventilated cable channels run horizontally or vertically	43
	Sheathed multi-core cables direct in insulating walls	51
	Sheathed single-core or multi-core cables direct in masonry without added mechanical protection	52
	Sheathed single-core or multi-core cables direct in masonry — with added mechanical protection.	53

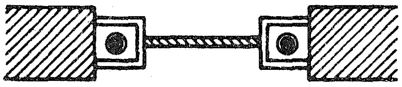
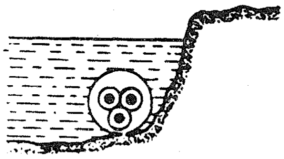
(*Continued*)

TABLE 4 EXAMPLES OF WIRING SYSTEMS — *Contd*

EXAMPLE	DESCRIPTION	REF
 	Sheathed single-core or multi-core cables in conduits or cable ducting in the ground	61
	Sheathed single-core or multi-core cables in the ground without added mechanical protection	62
	Sheathed single-core or multi-core cables in the ground with added mechanical protection	63
	Insulated conductors run in mouldings	71
	Insulated conductors in skirting trunking	72
	Insulated conductors in conduits or sheathed single core of multicore cables in architraves	73

(*Continued*

TABLE 4 EXAMPLES OF WIRING SYSTEMS — *Contd*

EXAMPLE	DESCRIPTION	REF
	Insulated conductors in conduits or sheathed single-core or multi-core cables in window frame	74
	Sheathed cables immersed in water	81

APPENDIX B

(*Clause* 8 3.5.8)

METHODS OF INTERNAL WIRING

B-1. CLEATED WIRING SYSTEM

B-1.1 General — This system shall not be employed for wiring on damp walls or ceiling.

B-1.2 Accessibility — All cleated wiring shall be run, as far as practicable, so as to be visible except in positions where they would be liable to mechanical injury and where they are less than 1·5 m above the floor, in which cases they shall be adequately protected.

B-1.3 Types of Cables — Vulcanized rubber insulated cables; plastic (PVC and polyethylene) insulated cables, braided or unbraided; and any other approved insulated cables shall be used without any further protection.

B-1.4 Cleats — All cleats shall consist of two parts, a base piece and a cap. A special pattern of cleat may be used, if necessary, where conductors pass round corners, so that there may be no risk of the conductors touching the wall owing to the sagging or stretching. Cleats shall be fixed at distances not greater than 60 cm apart and at regular intervals.

B-1.5 Where cleated wiring is laid along iron joist or any metal, spacing between such metal and porcelain cleats shall be inserted either with varnished wood fillet or varnished wood clamp securely fixed as would be approved so as to prevent conductors coming in contact with such metal along which they are passing.

B-1.6 Fixing of Cleats

B-1.6.1 In ordinary cases, cleats shall be attached to plugs arranged in a suitable manner.

B-1.6.2 Where practicable the same method shall be adopted in the cases of stone walls, but when owing to irregular coursing or other reasons it is impracticable to fix the cleats in a regular and workman like manner, a wood batten shall be provided and fixed with not less than one plug per 1·25 m run. The batten shall be of seasoned teak or other suitable seasoned hardwood 2 cm thick and 2·5 cm wider than the cleat used, it shall be chamfered on the edges, wrought all over and varnished with two coats of varnish conforming to IS : 347-1975* or painted as may be required.

B-1.7 Distance Between Wires — For voltages up to 250 volts, cleats shall be of such dimensions that in the case of branch loads, conductors shall not be less than 2·5 cm apart centre to centre and in the case of submains not less than 4 cm apart centre to centre, provided that this shall not apply, if the cable used is twin-core. Care shall be taken in selecting size of cleats particularly for branch distribution wiring where two-way and three-way porcelain cleats are essential, and the difference in size shall be reasonable. Care shall also be taken that grooves of porcelain cleats do not compress the insulation nor be too wide for a very loose fit. Under no circumstances two wires shall be placed in one groove of porcelain cleats.

B-1.8 Crossing of Conductors

B-1.8.1 Where cleated conductors cross each other they shall be separated by an insulating bridging piece, which will rigidly maintain a distance of at least 1·3 cm between the conductors except when the cable used is twin-core.

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*Specification for varnish, shellac, for general purposes (*first revision*).

B-1.8.2 In open type wiring, joint cut-outs or fuse or fuse cut-outs shall not be inserted for any purpose, but where joints are required for connecting bifurcating wires, junction boxes of wooden or other insulating material with porcelain connectors inside shall be used.

B-1.9 Protection Near Floor

B-1.9.1 No cleated wiring shall be left unprotected up to 1·5 m above floor level. When brought through the floor it shall be enclosed in conduit in the manner specified in **B-2.9**.

B-1.9.2 As far as possible, no open type of wiring shall run within floors, walls, partitions, ceilings, roof spaces or other concealed spaces in which they are not normally open to view; in such cases conductors shall be carried through steel conduit pipe [*see* IS : 9537 (Part 2)-1981*] with all screwed accessories, keeping mechanical continuity throughout the entire layout, and such pipe work shall be earthed and properly bushed on all open ends to prevent abrasion of cables.

B-1.9.3 At the time of laying and drawing of conductors, care shall be taken to keep the wires straight, tight and rigid without any twist.

B-1.9.4 All wooden fittings, such as boards, blocks, etc, shall be of well-seasoned teak wood or of suitable insulating material and shall be of double type, that is, separate base and top. The wooden boards shall be well varnished on all sides (both inside and outside) and may be mounted with suitable porcelain insulators behind the boards.

B-2. WOOD CASING WIRING SYSTEM

B-2.1 General — This system of wiring is suitable for low voltage installation where vulcanized rubber insulated cables, plastic insulated cables or other suitable insulated cables shall be used in the wiring work and carried within wood casing enclosure. Wood casing wiring system shall not be used in damp places or in ill-ventilated places, unless suitable precautions are taken.

B-2.2 Material and Pattern of Casing — All casing shall be of seasoned teak wood or any other approved hardwood, free from knots, shakes, saps, or other defects, all sides planed with smooth finish, and all sides well varnished (both inside and outside) with pure shellac varnish (*see* IS : 347-1975†). The casing shall have grooved body with beaded or plain moulded cover as desired.

B-2.3 Dimensions of Casing — The sizes of casing and capping for various sizes of 250 V grade insulated cables in a groove shall be in accordance with those specified in Table 5.

B-2.4 Bunching of Circuits — Conductors of opposite polarity or different phases shall not be bunched in one groove in wood casing.

NOTE — Lengths of conductors of the same polarity or phase, and free joints, may be bunched, if so desired.

B-2.5 Attachment of Casing to Wall and Ceiling — All casing shall be fixed by means of suitable flat-head wood screws to plugs at an interval not exceeding 90 cm for sizes up to 64 mm casing and not exceeding 60 cm for sizes above 64 mm casing. Screw heads shall be countersunk within the dividing wall of the grooves (in the case of three-grooved casing, two screws shall be inserted on the two dividing walls in a workmanlike manner). All casing shall be spaced from the wall or ceiling by means of porcelain disc insulators not less than 6·5 mm thick. Casing shall be used only on dry walls and ceilings avoiding outside walls, as far as possible, and shall not be buried in walls or ceilings under plaster, nor fixed in proximity to gas, steam or water pipes or immediately below the latter. Casing under steel joists shall be secured by hoop-iron or by approved wood clamps, and spaced with disc insulators.

B-2.6 Attachment of Capping — All capping shall be attached to the casing (after all insulated wires are laid inside grooves) by round-head screws (rust resisting) fixed on edges and screwed to outer walls of the casing at an interval not exceeding 15 cm crosswise (that is, 30 cm between two successive screws on each side) for all sizes up to 64 mm casing and capping. For sizes above 64 mm similar additional round-head screws shall be fixed on the centre-wall (or alternative walls in cases of 3 grooves) at an interval of 45 cm.

NOTE — Care shall be taken in fixing screws on cappings so that they do not pierce through the walls of casing and damage the insulation.

B-2.7 Joints in Casing and Capping — Casing and capping shall be run in lengths as long as possible. All joints shall be scarfed or cut diagonally in longitudinal section and shall be smoothed down by fitting to make joints a very close fit as far as possible. They shall be secured at joints with two or more screws as would be necessary. Joints in capping shall not overlap those in the casing.

B-2.8 Layout of Wood Casing Wiring — Layout of wood casing wiring shall be such as to avoid corners as far as possible and avoid crossing of conductors inside the casing. Where conductors have to cross corners, teak wood solid corner pieces of a radius not less than 7·5 cm and of the same width as that of casing with the same finish as that of capping shall be used with grooves at the bottom for conductors. Where crossing of wires is unavoidable and a junction box is not used, a bridge piece of casing shall be fixed on the top of casing with neat finish and shall pass conductors avoiding crossing.

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*Specification for conduits for electrical installations: Part 2 Rigid steel conduits.

†Specification for varnish, shellac for general purposes (*first revision*).

TABLE 5 SIZE OF WOOD CASING AND CAPPING, AND NUMBER OF CABLES THAT MAY BE DRAWN IN ONE GROOVE OF THE CASING

(*Clause* B-2.3)

Width of casing or capping, mm	38	44	51	64	76	89	102
No. of grooves	2	2	2	2	2	2	2
Width of grooves, mm	6	6	9	13	16	16	19
Width of dividing fillet, mm	12	12	13	18	24	35	38
Thickness of outer wall, mm	7	10	10	10	10	11	13
Thickness of casing, mm	16	16	19	19	25	32	32
Thicknes of capping, mm	6	6	10	10	10	13	13
Thickness of the back under the groove, mm	6	6	6	10	10	10	13
Length, m				2·5 to 3·0			

SIZE OF CABLE		NUMBER OF CABLES THAT MAY BE DRAWN IN ONE GROOVE						
Nominal Cross Sectional Area, mm²	Number and Diameter (in mm) of Wires							
1·0	1/1·12*	2	2	3	3	9	12	12
1·5	1/1·40	1	1	2	2	8	12	12
2·5	1/1·80	1	1	2	2	5	10	10
	3/1·60*							
4	1/2·24	—	—	2	2	5	8	9
	7/1·85*							
6	1/2·80	—	—	1	1	4	6	6
	7/1·06							
10	1/3·55†	—	—	1	1	3	5	5
	7/1·40	—	—	1	1	2	3	4
16	7/1·70	—	—	—	—	1	2	2
25	7/2·24	—	—	—	—	1	1	1
35	7/2·50	—	—	—	—	1	1	1
50	7/3·00†	—	—	—	—	1	1	1
	19/1·80						1	1

*For copper conductors only.
†For aluminium conductors only.

B-2.9 Passing Through Floors — Where conductors pass through floors, they shall be carried in an approved heavy gauge conduit properly bushed at both ends. The conduit shall be carried 1·5 m above floor level and 2·5 cm below ceiling level and neatly entered into the casing, which shall, if so required, be suitably protected at the floor level. The conduit pipe shall be securely earthed.

B-2.10 Casing Round Mouldings or Decorations — This shall be considered as special decoration work and carried out in consultation with the architect or the engineer-in-charge of construction work and with his approval.

B-2.11 Painting and Varnishing — All casing and capping shall be given, before erection, internally and on the back, two coats of varnish conforming to IS : 347-1975*. In addition all casing together with capping after erection shall be painted or varnished to the desired finish.

B-3. TOUGH RUBBER-SHEATHED OR PVC SHEATHED WIRING SYSTEM

B-3.1 General — Wiring with tough rubber-sheathed cables is suitable for low voltage installations, and shall not be used in places exposed to sun and rain nor in damp places, unless wires are sheathed in protective covering against atmosphere and well protected to withstand dampness. Wiring with PVC-sheathed cables is suitable for medium voltage installation and may be installed directly under exposed conditions of sun and rain or damp places. This system of wiring is suitable in situations where acids and alkalis are likely to be present. Where attack from whiteants (termite) is prevalent, anti-termite treatment shall be given.

All sheathed cables on brick walls, stone or plaster walls and ceilings, steel joists, or any structural steel work shall be run on well-seasoned and vasnished, straight teak wood battens finished not less than 10 mm thick and the width of which is such as to suit total width of cables laid on the batten. Prior to erection, these shall be painted

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*Specification for varnish, shellac for general purposes (*first revision*).

with one coat of varnish or suitable paint matching with the surroundings. These battens shall be secured to the walls and ceilings by flat-head wood screws to wood plugs or other plugs at an interval not exceeding 75 cm; the flat-head wood screws shall be countersunk within wood batten and smoothed down with file.

B-3.2 Link Clips — Link clips shall conform to IS : 2412-1975*. Link clips shall be so arranged that one single clip shall not hold more than two twin-core TRS or PVC-sheathed cables up to 1·5 mm² above which a single clip shall hold a single twin-core cable. The clips shall be fixed on varnished wood battens with any rust resisting pins or screws and spaced at intervals of 10 cm in the case of horizontal runs and 15 cm in the case of vertical runs. For the wiring and runs of mains exposed to heat and rain, clips specially made for outdoor use from a durable metal, resistant to weather and atmospheric corrosion, shall be used.

B-3.3 Protection of TRS or PVC-Sheathed Wiring from Mechanical Damage

B-3.3.1 In cases where there are chances of any damage to the wirings, such wirings shall be covered with sheet metal protective covering, the base of which is made flush with the plaster or brickwork, as the case may be, or the wiring shall be drawn through a conduit complying with all requirements of conduit wiring system (*see* **B-5**).

B-3.3.2 Such protective covering shall in all cases be fitted on all downdrops within 1·5 m from the floor.

B-3.4 Bends in Wiring — The wiring shall not in any circumstances be bent so as to form a right angle but shall be rounded off at the corners to a radius not less than six times the overall diameter of the cable.

B-3.5 Passing Through Floors — All cables taken through floors shall be enclosed in an insulated heavy gauge steel conduit extending 1·5 m above the floor and flush with the ceiling below, or by means of any other approved type of metallic covering. The ends of all conduits or pipes shall be neatly bushed with porcelain, wood or other approved material.

B-3.6 Passing Through Walls — The method to be adopted shall be according to good practice. There shall be one or more conduits of adequate size to carry the conductors (*see* Table 6 and Table 7). The conduits shall be neatly arranged so that the cables enter them straight without bending.

B-3.7 Buried Cables — The tough rubber-sheathed cables shall not be buried directly in plaster; where so specified, they may be taken in teak wood channelling of ample capacity or cement chase or conduit buried in the wall.

B-3.8 Stripping of Outer Covering — While cutting and stripping of the outer covering of the cables, care shall be taken that the sharp edge of the cutting instrument does not touch the rubber or PVC sheathed insulation of conductors. The protective outer covering of the cables shall be stripped off near connecting terminals, and this protective covering shall be maintained up to the close proximity of connecting terminals as far as practicable. Care shall be taken to avoid hammering on link clips with any metal instruments, after the cables are laid. Where junction boxes are provided, they shall be made moisture-proof with an approved plastic compound.

B-3.9 Painting — If so required, the tough rubber-sheathed wiring shall, after erection, be painted with one coat of oil-less paint or distemper of suitable colour over a coat of oil-less primer, and the PVC-sheathed wiring shall be painted with a synthetic enamel paint of quick drying type.

B-4. METAL-SHEATHED WIRING SYSTEM

B-4.1 General — Metal-sheathed wiring system is suitable for low voltage installations, and shall not be used in situations where acids and alkalis are likely to be present. Metal-sheathed wiring may be used in places exposed to sun and rain provided no joint of any description is exposed; this system may be installed in damp places with approved protection against dampness coming in contact with open ends of cables.

B-4.2 Link Clips — Link clips shall conform to IS : 2412-1975* and shall be so arranged that one single clip shall not hold more than two twin-core metal-sheathed cables up to 1·5 mm², above which a single clip shall hold a single twin-core cable. The clips shall be fixed on varnished wood battens with brass pins or brass screws and placed at intervals of 10 cm in the case of horizontal runs and 15 cm in the case of vertical runs. For the wiring and runs of mains exposed to heat and rain, clips specially made for the outdoor use from a durable metal, resistant to weather and atmospheric corrosion, shall be used.

B-4.3 Attachment to Walls and Ceilings—All metal-sheathed cables on brick walls, stone walls or plastered walls and ceilings; steel joists or any structural steel work shall be run on well-seasoned and perfectly straight teak wood battens of not less than 10 mm finished thickness, which have been well varnished on four sides. The width of teak wood battens shall be such as to suit the total width of cables laid on the batten. Prior to erection these shall be painted with one coat of varnish (*see* IS : 347-1975†) or suitable paint of colour to match with the surroundings These battens shall be secured to the walls and ceilings by flat-head wood screws to wood plugs or other approved plugs at an interval not exceeding 75 cm; the flat-head wood screws shall be countersunk within wood batten and smoothed down with file.

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*Specification for link clips for electrical wiring (*first revision*).

*Specification for link clips for electrical wiring (*first revision*).

†Specification for varnish, shellac, for general purposes (*first revision*).

B-4.4 Wiring on Rolled Steel Joists — Where wiring is to be carried along the face of rolled steel joists, a batten shall first be laid on the joists and clipped to it as inconspicuously as possible. The wiring shall be fixed to the batten in the ordinary way.

B-4.5 Protection of Wiring from Mechanical Damage

B-4.5.1 In cases where there are chances of any damage to the wiring, such wiring shall be covered with sheet metal protective covering, the base of which is made flush with the plaster of brickwork, as the case may be, or the wiring shall be drawn through a steel conduit pipe by complying with all requirements of conduit system of wiring (*see* B-5).

B-4.5.2 The protective covering shall in all cases be carried right through the entire length of such doubtful positions.

B-4.6 Joints — Where joint-box system is specified, joints shall be made by means of connectors, insulated with porcelain, or other approved material and enclosed in joint-boxes. The joint-boxes shall be so constructed as to prevent insects from entering them, and to allow the white washing of the walls without water having access to the connectors. All cables shall be bonded through, or across these boxes. Bonding connections shall be so arranged as not to come in contact with plaster.

B-4.7 Stripping of Insulation and Outer Covering

B-4.7.1 When rubber or PVC insulation has to be stripped for joints, the metal sheathing shall be nicked only, not cut, and the insulation between the metal sheath and the conductors shall be of rubber or PVC sheath only. All tape shall be stripped off. Where paper-insulated metal-sheathed cable is used, all openings in the same shall be efficiently sealed.

B-4.7.2 While cutting and stripping of the outer covering of the cables, care shall be taken that the sharp edge of cutting instrument does not touch the rubber or PVC insulation of conductors. While connecting conductors to the connecting terminals of accessories, care shall be taken to remove cotton tape covering from the top of rubber insulation of cable. The cotton tape covering shall always remain inside lead covering of cables.

B-4.8 Passing Through Floors — All cables taken through floors shall be enclosed in an insulated steel conduit extending 1·5 m above the floor and flush with the ceiling below, or protected by means of any other approved type of metallic covering. The ends of all conduits or pipes shall be neatly bushed with porcelain, wood or other approved material.

B-4.9 Passing Through Walls — The method to be adopted shall be in accordance with good practice. There shall be one or more conduits of adequate size to carry the conductors (*see* Tables 6 and 7). The conduit(s) shall be neatly arranged so that the cables enter them straight without bending.

B-4.10 Burried Cables — Metal sheathed cables shall in no case be burried directly in the plaster or under any masonry work.

B-4.11 Earthing — Precautions shall be taken to ensure that all lead sheathing including portable appliance with exposed metal parts, together with all joint-boxes and other similar receptacles are efficiently earthed and made electrically continuous throughout their lengths by means of soldered joints or approved suitable clamps or, alternatively with earth continuity conductors (each bonded cables) specially manufactured for the purpose. The earthing shall extend to all main switches, distribution boards, etc, in compliance with Indian Electricity Rules, 1956, as well as manufacturers' design and instructions in connection with earthing of all insulated microgap main switches or similar fittings.

B-4.12 Resistance — The electrical resistance of the metal sheathing together with the resistance of the earthing lead, measured from the connection with the earth electrode to any other position in the completed installation shall not exceed one ohm.

B-4.13 Painting — Where required, all metal-sheathed wiring or its protective covering when such is fitted, shall be neatly painted after erection with two coats of any suitable paint.

B-5. CONDUIT WIRING SYSTEM

B-5.1 Surface Conduit Wiring System with Rigid Steel Conduits

B-5.1.1 *Type and Size of Conduit* — All conduit pipes shall be conforming to IS : 1653-1972*, finished with galvanized or stove enamelled surface. All conduit accessories shall be of threaded type and under no circumstances pin grip type or clamp type accessories be used. No steel conduit less than 16 mm in diameter shall be used. The number of insulated conductors that can be drawn into rigid steel conduit are given in Table 6.

B-5.1.2 *Bunching of Cables* — Unless otherwise specified, insulated conductors of ac supply and dc supply shall be bunched in separate conduits. For lighting and small power outlet circuits phase segregation in separate conduits is recommended.

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*Specification for rigid steel conduits for electrical wiring (*second revision*).

TABLE 6 MAXIMUM PERMISSIBLE NUMBER OF 250 V GRADE SINGLE-CORE CABLES THAT CAN BE DRAWN INTO RIGID STEEL CONDUITS

(*Clauses* B-3.7, B-4.9 *and* B-5.1.1)

Size of Cable		Size of Conduit, mm													
Nominal Cross-Sectional Area, mm^2	Number and Diameter of Wires, mm	16		20		25		32		40		50		63	
		Number of Cables, *Max*													
		S	B	S	B	S	B	S	B	S	B	S	B	S	B
1·0	1/1·12*	5	4	7	5	13	10	20	14	—	—	—	—	—	—
1·5	1/1·40	4	3	7	5	12	10	20	14	—	—	—	—	—	—
2·5	1/1·80 3/1·06*	3	2	0	5	10	8	18	12	—	—	—	—	—	—
4	1/2·24 7/0·85*	3	2	4	3	7	8	12	10	—	—	—	—	—	—
6	1/2·80 7/1·06*	2	—	3	2	6	5	10	8	—	—	—	—	—	—
10	11/3·55†	—	—	2	—	5	4	8	7	—	—	—	—	—	—
	7/1·40*	—	—	2	—	4	3	6	5	8	6	—	—	—	—
16	7/1·70	—	—	—	—	2	—	4	3	7	6	—	—	—	—
25	7/2·24	—	—	—	—	—	—	3	2	5	4	8	6	9	7
35	7/2·50	—	—	—	—	—	—	2	—	4	3	7	5	8	6
50	7/3·00† 19/1·80	—	—	—	—	—	—	—	—	2	—	5	4	6	5

NOTE 1 — The table shows the maximum capacity of conduits for the simultaneouly drawing of cables. The columns headed *S* apply to runs of conduit which have distance not exceeding 4·25 m between drawn-in boxes, and which do not deflect from the straight by an angle of more than 15°. The columns headed *B* apply to runs of conduit which deflect from the straight by an angle of more than 15°.

NOTE 2 — In case an inspection type draw-in box has been provided and if the cable in first drawn through one straight conduit, then through the draw-in box, and then through the second straight conduit, such systems may be considered as that of a straight conduit even if the conduit deflects through the straight by more than 15°.

*For copper conductors only.

†For aluminium conductors only.

B-5.1.3 *Conduit Joints* — Conduit pipes shall be joined by means of screwed couplers and screwed accessories only (*see* IS : 2667-1976*). In long distances straight runs of conduit, inspection type couplers at reasonable intervals shall be provided or running threads with couplers and jam-nuts (in the latter case the bare threaded portion shall be treated with anti-corrosive preservative) shall be provided. Threaded on conduit pipes in all cases shall be between 11 mm to 27 mm long sufficient to accommodate pipes to full threaded portion of couplers or accessories. Cut ends of conduit pipes shall have no sharp edges nor any burrs left to avoid damage to the insulation of conductors while pulling them through such pipes.

B-5.1.4 *Protection Against Dampness* — In order to minimize condensation or sweating inside the tube, all outlets of conduit system shall be properly drained and ventilated, but in such a manner as to prevent the entry of insects as far as possible.

B-5.1.5 *Protection of Conduit Against Rust* — The outer surface of the conduit pipes, including all bends, unions, tees, junction boxes, etc, forming part of the conduit system shall be adequately protected against rust particularly when such system is exposed to weather. In all cases, no bare threaded portion of conduit pipe shall be allowed unless such bare threaded portion is treated with anti-corrosive preservative or covered with suitable plastic compound.

B-5.1.6 *Fixing of Conduit* — Conduit pipes shall be fixed by heavy gauge saddles, secured to suitable wood plugs or other plugs with screws in an approved manner at an interval of not more than one metre, but on either side of couplers or bends or similar fittings, saddles shall be fixed at a distance of 30 cm from the centre of such fittings.

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*Specification for fittings for rigid steel conduits for electrical wiring (*first revision*)

B-5.1.7 *Bends in Conduit* — All necessary bends in the system including diversion shall be done by bending pipes; or by inserting suitable solid or inspection type normal bends, elbows or similar fittings; or fixing cast-iron inspection boxes whichever is more suitable. Conduit fittings shall be avoided as far as possible on conduit system exposed to weather; where necessary, solid type fittings shall be used. Radius of such bends in conduit pipes shall not be less than 7·5 cm. No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet, the bends at the outlets not being counted.

B-5.1.8 *Outlets*—All outlets for fittings, switches, etc, shall be boxes of suitable metal or any other approved outlet boxes for either surface mounting or flush mounting system.

B-5.1.9 *Conductors* — All conductors used in conduit wiring shall preferably be stranded. No single-core cable of nominal cross-sectional area greater than 130 mm² enclosed alone in a conduit and used for alternating current.

B-5.1.10 *Erection and Earthing of Conduit* — The conduit of each circuit or section shall be completed before conductors are drawn in. The entire system of conduit after erection shall be tested for mechanical and electrical continuity throughout and permanently connected to earth conforming to the requirements specified in this standard by means of suitable earthing clamp efficiently fastened to conduit pipe in a workmanlike manner for a perfect continuity between each wire and conduit. Gas or water pipes shall not be used as earth medium. If conduit pipes are liable to mechanical damage they shall be adequately protected.

B-5.1.11 Inspection type conduit fittings such as inspection boxes, draw boxes, bends, elbows and tees shall be so installed that they can remain accessible for such purposes as withdrawal of existing cables or the installing of additional cables.

B-5.2 Recessed Conduit Wiring System with Rigid Steel Conduits — Recessed conduit wiring system shall comply with all the requirements for surface conduit wiring system specified in **B-5.1.1** to **B-5.1.9** and in addition, conform to the requirements specified below.

B-5.2.1 *Making of Chase* — The chase in the wall shall be neatly made and be of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, chases shall be provided in wall, ceiling, etc, at the time of their construction and shall be filled up neatly after erection of conduit and brought to the original finish of the wall.

B-5.2.2 *Fixing of Conduit in Chase* — The conduit pipe shall be fixed by means of staples or by means of saddles not more than 60 cm apart. Fixing of standard bends or elbows shall be avoided as far as practicable and all curves maintained by bending the conduit pipe itself with a long radius which will permit easy drawing-in of conductors. All threaded joints of rigid steel conduit shall be treated with preservative compound to secure protection against rust.

B-5.2.3 *Inspection Boxes* — Suitable inspection boxes shall be provided to permit periodical inspection and to facilitate removal of wires, if necessary. These shall be mounted flush with the wall. Suitable ventilating holes shall be provided in the inspection box covers. The minimum sizes of inspection boxes shall be 75 mm × 75 mm.

B-5.2.4 *Types of Accessories to be Used* — All outlet, such as switches and wall sockets, may be either of flush mounting type or of surface mounting type.

B-5.2.4.1 *Flush mounting type* — All flush mounting outlets shall be of cast iron or mild steel boxes with a cover of insulating material or shall be a box made of a suitable insulating material. The switches and other outlets shall be mounted on such boxes. The metal box shall be efficiently earthed with conduit by a suitable means of earth attachment.

B-5.2.4.2 *Surface mounting type* — If surface mounting type outlet box is specified, it shall be of any suitable insulating material and outlets mounted in an approved manner.

B-5.2.5 When crossing through expansion joints in buildings, the conduit sections across the joint may be through flexible conduits of the same size, as the rigid conduit.

B-5.3 Conduit Wiring System with Rigid Non-metallic Conduits — Rigid non-metallic conduits are used for surface, recessed and concealed conduit wiring.

B-5.3.1 *Type and Size* — All non-metallic conduits used shall conform to IS : 9537 (Part 3)-1987*. The conduit may be either threaded type or plain type as specified in IS : 9537 (Part 3)-1987* and shall be used with the corresponding accessories (*see* IS : 3419-1976†).

B-5.3.2 *Bunching of Cables* — Conductors of ac supply and dc supply shall be bunched in separate conduits. For lighting and small power outlet circuits phase segregation in separate circuits is recommended. The number of insulated cables that may be drawn into the conduits are given in Table 7. In this table the space factor does not exceed 40 percent.

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*Specification for conduits for electrical installations: Part 3 Rigid plain conduits of insulating materials.

†Specification for fittings for rigid non-metallic conduits (*first revision*).

TABLE 7 MAXIMUM PERMISSIBLE NUMBER OF 250 VOLTS GRADE SINGLE-CORE CABLES THAT MAY BE DRAWN INTO RIGID NON-METALLIC CONDUITS

(*Clauses* B-3.7, B-4.9 *and* B-5.3.2)

Size of Cable		Size of Conduit (mm)					
Nominal Cross-Sectional Area mm^2	Number and Diameter (in mm) of Wires	16	20	25	32	40	50
		Number of Cables, *Max*					
1·0	1/1·12*	5	7	13	20	—	—
1·5	1/1·40	4	6	10	14	—	—
2·5	(1/1·80) (3/1·06*)	3	5	10	14	—	—
4	(1/2·24) (7/0·85*)	2	3	6	10	14	—
6	(1/2·80) (7/1·40*)	—	2	5	9	11	—
10	(1/3·55†) (7/1·40*)	—	—	4	7	9	—
16	7/1·70	—	—	2	4	5	12
25	7/2·24	—	—	—	2	2	6
35	7/2·50	—	—	—	—	2	5
50	7/3·00†	—	—	—	—	2	5
	19/1·80	—	—	—	—	2	3

*For copper conductors only.

†For aluminium conductors only.

B-5.3.3 *Conduit Joints* — Conduits shall be joined by means of screwed or plain couplers depending on whether the conduits are screwed or plain. Where there are long runs of straight conduit, inspection type couplers shall be provided at intervals. For conduit fittings and accessories reference may be made to IS : 3419-1976*.

B-5.3.4 *Fixing of Conduits* — The provisions of **B-5.1.6** shall apply except that the spacing between saddles or supports is recommended to be 60 cm for rigid non-metallic conduits.

B-5.3.5 *Bends in Conduits* — Wherever necessary, bends or diversions may be achieved by bending the conduits (*see* **B-5.3.9**) or by employing normal bends, inspection bends, inspection boxes, elbows or similar fittings.

B-5.3.6 Conduit fittings shall be avoided, as far as possible, on outdoor systems.

B-5.3.7 *Outlets* — In order to minimize condensation or sweating inside the conduit, all outlets of conduit system shall be properly drained and ventilated, but in such a manner as to prevent the entry of insects.

B-5.3.8 For use with recessed conduit wiring system the provisions of **B-5.2.1** to **B-5.2.4** shall apply.

B-5.3.9 Heat may be used to soften the conduit for bending and forming joints in case of plain conduits. As the material softens when heated, sitting of conduit in close proximity to hot surfaces should be avoided. Caution should be exercised in the use of this conduit in locations where the ambient temperature is 50°C or above. Use of such conduits in places where ambient temperature is 60°C or above is prohibited.

B-5.3.10 Non-metallic conduit systems shall be used only where it is ensured that they are:

a) suitable for the extremes of ambient temperature to which they are likely to be subjected in service,

b) resistant to moisture and chemical atmospheres, and

c) resistant to low temperature and sunlight effects.

For use underground, the material shall be resistant to moisture and corrosive agents.

NOTE — Rigid PVC conduits are not suitable for use where the normal working temperature of the conduits and fittings may exceed 55°C. Certain types of rigid PVC conduits and their associated fittings are unsuitable for use where the ambient temperature is likely to fall below −5°C.

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*Specification for fittings for rigid non-metallic conduits (*first revision*).

APPENDIX C

(*Clauses* 11.7 *and* 12.3)

GUIDELINES FOR SPECIFIC EQUIPMENT FITTINGS AND ACCESSORIES

C-0. GENERAL

C-0.1 All equipment, fittings and accessories, materials, etc, selected for the wiring installation shall conform to the relevant Indian Standards wherever these exist.

C-1. CEILING ROSES AND SIMILAR ATTACHMENTS

C-1.1 A ceiling rose or any other similar attachment shall not be used on a circuit, the voltage of which normally exceeds 250 V.

C-1.2 Normally, only one flexible cord shall be attached to a ceiling rose. Specially designed ceiling roses shall be used for multiple pendants.

C-1.3 A ceiling rose shall not embody fuse terminal as an integral part of it.

C-2. SOCKET-OUTLETS AND PLUGS

C-2.1 Each 15 A socket-outlet provided in buildings for the use of domestic appliances such as air-conditioner, water cooler etc, shall be provided with its own individual fuse, with suitable discrimination with back-up fuse or miniature circuit-breaker provided in the distribution/sub-distribution board. The socket-outlet shall not necessarily embody the fuse as an integral part of it.

C-2.2 Each socket-oulet shall also be controlled by a switch which shall preferably be located immediately adjacent thereto or combined therewith.

C-2.3 The switch controlling the socket-outlet shall be on the live side of the line.

C-2.4 Ordinary socket-outlet may be fixed at any convenient place at a height above 20 cm from the floor level and shall be away from danger of mechanical injury.

NOTE — In situations where a socket-outlet is accessible to children, it is necessary to install an interlocked plug and socket or alternatively a socket-outlet which automatically gets screened by the withdrawal of plug. In industrial premises socket-outlet of rating 20A and above shall preferably be provided with interlocked type switch.

C-2.5 In an earthed system of supply, a socket-outlet with plug shall be of three-pin type with the third terminal connected to the earth. When such socket-outlets with plugs are connected to any current consuming device of metal or any non-insulating material or both, conductors connecting such current-consuming devices shall be of flexible cord with an earthing core and the earthing core shall be secured by connecting between the earth terminal of plug and the body of current-consuming devices.

In industrial premises three phase and neutral socket-outlets shall be provided with a earth terminal either of pin type or scrapping type in addition to the main pins required for the purpose.

C-2.6 In wiring installations, metal clad switch, socket-outlet and plugs shall be used for power wiring.

C-3. LIGHTING FITTINGS

C-3.1 A switch shall be provided for control of every lighting fitting or a group of lighting fittings. Where control at more than one point is necessary as many two way or intermediate switches may be provided as there are control points.

C-3.2 In industrial premises lighting fittings shall be supported by suitable pipe/conduits, brackets fabricated from structural steel, steel chains or similar materials depending upon the type and weight of the fittings. Where a lighting fitting is supported by one or more flexible cords, the maximum weight to which the twin flexible cords may be subjected shall be as follows:

Nominal Cross-Sectional Area of Twin Flexible Cord	*Number and Diameter in mm of Wires*	*Maximum Permissible Weight*
mm²		kg
0·5	16/0·2	2
0·75	24/0·2	3
1·0	32/0·2	5
1·5	48/0·2	5·3
2·5	80/0·2	8·8
4	128/0·2	14·0

C-3.3 No flammable shade shall form a part of lighting fittings unless such shade is well protected against all risks of fire. Celluloid shade or lighting fitting shall not be used under any circumstances.

C-4. FITTING-WIRE

C-4.1 The use of fittings-wire shall be restricted to the internal wiring of the lighting fittings. Where fittings-wire is used for wiring fittings, the sub-circuit loads shall terminate in a ceiling rose or box with connectors from which they shall be carried into the fittings.

C-5. LAMPHOLDERS

C-5.1 Lampholders for use on brackets and the like shall be in accordance with IS : 1258-1979* and all those for use with flexible pendants shall be provided with cord grips. All lampholders shall be provided with shade carriers. Where centre-contact Edison screw lampholders are used, the outer or screw contacts shall be connected to the 'middle wire', the neutral, the earthed conductor of the circuit.

C-6. OUTDOOR LAMPS

C-6.1 External and road lamps shall have weather-proof fittings of approved design so as to effectively prevent the ingress of moisture and dust. Flexible cord and cord grip lampholders shall not be used where exposed to weather. In verandahs and similar exposed situations where pendants are used, these shall be of fixed rod type.

C-7. LAMPS

C-7.1 All lamps unless otherwise required and suitably protected, shall be hung at a height of not less than 2·5 m above the floor level. They shall be in accordance with the relevant Indian Standard.

C-7.1.1 Portable lamps shall be wired with flexible cord. Hand lamps shall be equipped with a handle of moulded composition or other material approved for the purpose. Hand lamps shall be equipped with a substantial guard attached to the lampholder or handle. Metallic guards shall be earthed suitably.

C-7.1.2 A bushing or the equivalent shall be provided where flexible cord enters the base or stem of portable lamp. The bushing shall be of insulating material unless a jacketted type of cord is used.

C-7.1.3 All wiring shall be free from short circuits and shall be tested for these defects prior to being connected to the circuit.

C-7.1.4 Exposed live parts within porcelain fixtures shall be suitably recessed and so located as to make it improbable that wires will come in contact with them. There shall be a spacing of at least 125 mm between live parts and the mounting plane of the fixture.

C-8. FANS, REGULATORS AND CLAMPS

C-8.1 Ceiling Fans — Ceiling fans including their suspension shall conform to IS : 374-1979† and to the following requirements:

a) Control of a ceiling fan shall be through its own regulator as well as a switch in series.

b) All ceiling fans shall be wired with normal wiring to ceiling roses or to special connector boxes to which fan rod wires shall be connected and suspended from hooks or shackles with insulators between hooks and suspension rods. There shall be no joint in the suspension rod, but if joints are unavoidable then such joints shall be screwed to special couplers of 5 cm minimum length and both ends of the pipes shall touch together within the couplers, and shall in addition be secured by means of split pins; alternatively, the two pipes may be welded. The suspension rod shall be of adequate strength to withstand the dead and impact forces imposed on it. Suspension rods should preferably be procured along with the fan.

c) Fan clamps shall be of suitable design according to the nature of construction of ceiling on which these clamps are to be fitted. In all cases fan clamps shall be fabricated from new metal of suitable sizes and they shall be as close fitting as possible. Fan clamps for reinforced concrete roofs shall be buried with the casting and due care shall be taken that they shall serve the purpose. Fan clamps for wooden beams, shall be of suitable flat iron fixed on two sides of the beam and according to the size and section of the beam one or two mild steel bolts passing through the beam shall hold both flat irons together. Fan clamps for steel joist shall be fabricated from flat iron to fit rigidly to the bottom flange of the beam. Care shall be taken during fabrication that the metal does not crack while hammering to shape. Other fan clamps shall be made to suit the position, but in all cases care shall be taken to see that they are rigid and safe.

NOTE — All fan clamps shall be so fabricated that fans revolve steadily.

d) Canopies on top and bottom of suspension rods shall effectively conceal suspensions and connections to fan motors, respectively.

e) The lead-in-wire shall be of nominal cross-sectional area not less than 1·0 mm^2 copper or 1·5 mm^2 aluminium and shall be protected from abrasion.

f) Unless otherwise specified, the clearance between the bottom-most point of the ceiling fan and the floor shall be not less than 2·4 m. The minimum clearance between the ceiling and the plane of the blades shall be not less than 300 mm.

C-8.2 Exhaust Fans — For fixing of an exhaust fan, a circular hole shall be provided in the wall to suit the size of the frame which shall be fixed by means of rag-bolts embedded in the wall. The

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*Specification for bayonet lampholders (*second revision*).

†Specification for electric ceiling type fans and regulators (*third revision*).

hole shall be neatly plastered with cement and brought to the original finish of the wall. The exhaust fan shall be connected to exhaust fan point which shall be wired as near to the hole as possible by means of a flexible cord, care being taken that the blades rotate in the proper direction.

C-9. ATTACHMENT OF FITTINGS AND ACCESSORIES

C-9.1 In wiring other than conduit wiring, all ceiling roses, brackets, pendants and accessories attached to walls or ceilings shall be mounted on substantial teak wood blocks twice varnished after all fixing holes are made in them. Blocks shall not be less than 4 cm deep. Brass screws shall only be used for attaching fittings and accessories to their base blocks.

C-9.2 Where teak or hardwood boards are used for mounting switches, regulators, etc, these boards shall be well varnished with pure shellac on all four sides (both inside and outside), irrespective of being painted to match the surroundings. The size of such boards shall depend on the number of accessories that could conveniently and neatly be arranged. Where there is danger of attack by termite, the boards shall be treated with suitable anti-termite compound and painted on both sides.

C-10. INTERCHANGEABILITY

C-10.1 Similar part of all switches, lampholders, distribution fuse-boards, ceiling roses, brackets, pendants, fans and all other fittings shall be so chosen that they are of the same type and interchangeable in each installation.

C-11. EQUIPMENT

C-11.1 Electrical equipment which form integral part of wiring intended for switching or control or protection of wiring installations shall conform to the relevant Indian Standards wherever they exist. Guidelines on their selection, installation and maintenance are given in separate Indian Standard codes of practice.

APPENDIX D

(*Clause* 11.7)

SPECIFIC GUIDANCE ON SELECTION OF EQUIPMENT WITH REGARD TO EXTERNAL INFLUENCES

D-1. EXTERNAL INFLUENCE

D-1.1 Electrical equipment shall be selected and erected in accordance with the requirements of Table 8, which indicates the characteristics of equipment necessary according to the external influences to which the equipment may be subjected, as such influences are defined in 4.

Equipment characteristics shall be determined either by a degree of protection or by conformity to tests.

D-1.2 If the equipment does not, by its constitution, have the characteristics relevant to the external influences of its location, it may nevertheless be used on condition that it is provided with appropriate additional protection in the erection of the installation. Such protection shall not adversely affect the operation of the equipment thus protected.

D-1.3 When different external iufluences occur simultaneously, they may have independent or mutual effect and the degree of protection shall be provided accordingly.

D-1.4 The selection of equipment according to external influences is necessary not only for proper functioning, but also to ensure the reliability of the measures of protection for safety complying with this Standard. Measures of protection afforded by the construction of equipment valid only for the given conditions of external influence if the corresponding equipment specification, tests are made in these conditions of external influence.

NOTE 1 — For the purposes of this standard, the following classes of external influence are conventionally regarded as normal:

AA Ambient temperature	AA4
AB Atmosphere humidity	Under consideration (but, for example, 50 percent relative humidity at 40°C).
Other environmental conditions (AC to AR)	XX1 for each parameter
Utilization and construction of buildings (B and C)	XX1 for each parameter XX2 for the parameter BC

NOTE 2 — The word 'normal' appearing in the third column of the table signifies that the equipment must generally satisfy applicable Indian Standards.

TABLE 8 ELECTRICAL EQUIPMENT

(*Clause* D-1.1)

CODE (1)	EXTERNAL INFLUENCE (2)	CHARACTERISTICS REQUIRED FOR SELECTION AND ERECTION OF EQUIPMENT (3)
A	*Environmental conditions*	
AA	*Ambient temperature*	
AA1	− 60°C to + 5°C	Specially designed equipment or appropriate arrangements*
AA2	− 40°C to + 5°C	
AA3	− 25°C to + 5°C	
AA4	− 5°C to + 40°C	Normal (in certain cases special precautions may be necessary)
AA5	+ 5°C to + 40°C	Normal
AA6	+ 5°C to + 60°C	Specially designed equipment or appropriate arrangements*
AB	*Atmospheric humidity*	Under consideration
AC	*Altitude*	
AC1	$\leqslant$ 2 000 m	Normal
AC2	$\geqslant$ 2 000 m	May necessitate special precautions such as the application of derating factors NOTE — For some equipment special arrangements may be necessary at altitude of 1 000 m and above.
AD	*Presence of water*	
AD1	Negligible	IP X0
AD2	Free-falling drops	IP X1
AD3	Sprays	IP X3
AD4	Splashes	IP X4
AD5	Jets	IP X5
AD6	Waves	IP X6
AD7	Immersion	IP X7
AD8	Submersion	IP X8
AE	*Presence of foreign solid bodies*	
AE1	Negligible	IP 0X
AE2	Small objects (2·5 mm)	IP 3X
AE3	Very small objects (1 mm)	IP 4X
AE4	Dust	IP 5X if dust penetration is not harmful to functioning of equipment IP 6X if dust should not penetrate equipment
AF	*Pressure of corrosive or polluting substances*	
AF1	Negligible	Normal
AF2	Atmospheric	According to the nature of substances (for example, satisfaction of salt mist test according to IS : 9000 (Part 11)-1983†.
AF3	Intermittent or accidental	Protection against corrosion according to equipment specification
AF4	Continuous	Equipment specially designed according to the nature of substances
AG	*Mechanical stresses* *Impact*	
AG1	Low severity	Normal, for example, household and similar equipment
AG2	Medium severity	Standard industrial equipment, where applicable, or reinforced protection

*May necessitate certain supplementary precautions (for example, special lubrication).

†Basic environmental testing procedures for electronic and electrical items: Part 11 Salt mist test.

(*Continued*)

TABLE 8 ELECTRICAL EQUIPMENT — *Contd*

CODE	EXTERNAL INFLUENCE	CHARACTERISTICS REQUIRED FOR SELECTION AND ERECTION OF EQUIPMENT
(1)	(2)	(3)
AG3	High severity	Reinfored protection
AH	*Vibration*	
AH1	Low severity	Normal
AH2	Medium severity	Specially designed equipment, or special arrangements
AH3	High severity	
AJ	*Other mechanical stresses*	Under consideration
AK	*Presence of flora and moulds growth or moulds growth*	
AK1	No hazard	Normal
AK2	Hazard	Special protection, such as: a) Increased degree of protection (*see* AE), b) Special materials or protective coating of enclosures, and c) Arrangements to exclude flora from location.
AL	*Pressure of fauna*	
AL1	No hazard	Normal
AL2	Hazard	Protection may include: a) An appropriate degree of protection against penetration of foreign solid bodies (*see* AE), b) Sufficient mechanical resistance (*see* AG), c) Precautions to exclude fauna from the location (such as cleanliness and use of pesticides), and d) Special equipment or protective coating of enclosures.
AM	*Electromagnetic, electrostatic, or ionizing influences*	
AM1	Negligible	Normal
AM2	Stray currents	Special protection, such as: a) Appropriate insulation, b) Special protective coatings, c) Cathodic protection, and d) Supplementary equipotential bonding.
AM3	Electromagnetics	Special protection such as: a) Spacings from radiation sources, b) Interposition of screens, and c) Enclosure by special materials.
AM4	Ionization	
AM5	Electrostatics	Special protection, such as: a) Appropriate insulation of the location, and b) Supplementary equipotential bonding.
AM6	Induction	Special protection, such as: a) Spacing from sources of induction current, and b) Interposition of screens.
AN	*Solar radiation*	
AN1	Negligible	Normal
AN2	Significant	Special arrangements, such as: a) Materials resistant to ultraviolet radiation, b) Special colour coatings, and c) Interposition of screens.

(*Continued*)

TABLE 8 ELECTRICAL EQUIPMENT — *Contd*

CODE	EXTERNAL INFLUENCE	CHARACTERISTICS REQUIRED FOR SELECTION AND ERECTION OF EQUIPMENT			
(1)	(2)	(3)			
AP	*Seismic effects*				
AP1	Negligible	Normal			
AP2	Low severity	Under consideration			
AP3	Medium severity				
AP4	High severity				
AQ	*Lighting*				
AQ1	Negligible	Normal			
AQ2	Indirect exposure	Under consideration			
AQ3	Direct exposure				
AR	*Wind*	Under consideration			
B	*Utilization*				
BA	*Capacity of persons*				
BA1	Ordinary	Normal			
BA2	Children	Equipment of degrees of protection higher than IP 2X. Inaccessability of equipment with external surface temperature exceeding. 80°C (60°C for nurseries and the like)			
BA3	Handicapped	According to the nature of the handicap			
BA4	Instructed	Equipment not protected against direct contact admitted solely in locations which are accessable only to duly authorized persons			
BA5	Skilled				
BB	*Electrical resistance of the human body*	Under consideration			
BC	*Contact of persons with earth potential*	Class of equipment according to IS : 9409-1980*			
		0-0I	I	II	III
BC1	None	A	Y	A	A
BC2	Low	A	A	A	A
BC3	Frequent	X	A	A	A
BC4	Continuous	Under consideration			
		A = Equipment permitted X = Equipment prohibited Y = Permitted if used as Class 0			
BD	*Conditions of evacuation in an emergency*				
BD1	Low density/easy exit	Normal			
BD2	Low density/difficult exit	Equipment made of material retarding the spread of flame and evolution of smoke and toxic gases. Detailed requirements are under consideration.			
BD3	High density/easy exit				
BD4	High density/difficult exit				
BE	*Nature of processed or stored materials*				
BE1	No significant risks	Normal			
BE2	Fire risks	Equipment made of material retarding the spread of flame. Arrangements such that a significant temperature rise or a spark within electrical equipment cannot initiate an external fire			
BE3	Explosion risks	According to the requirements of relevant Indian Standard on electrical apparatus for explosive atmospheres			
BE4	Contamination risks	Appropriate arrangements such as: a) Protection against falling debris from broken lamps and other fragile objects, and b) Screens against harmful radiation such as infrared or ultra-violet.			

*Classification of electrical and electronic equipment with regard to protection against electric shock.

(*Continued*)

TABLE 8 ELECTRICAL EQUIPMENT— *Contd*

CODE	EXTERNAL INFLUENCE	CHARACTERISTICS REQUIRED FOR SELECTION AND ERECTION OF EQUIPMENT
(1)	(2)	(3)
C	*Construction of Buildings*	
CA	*Construction materials*	
CA1	Non-combustible	Normal
CA2	Combustible	Under consideration
CB	*Building design*	
CB1	Negligible risks	Normal
CB2	Propagation of fire	Equipment made of material retarding the propagation of fire including fires not originating from the electrical installation. Fire barriers NOTE — Fire detectors may be provided.
CB3	Movement	Contraction or expansion joints in electrical wiring.
CB4	Flexible or unstable	Under consideration

APPENDIX E

(*Item* 12.2.1)

CHECK LIST OF INITIAL INSPECTION

E-0. GENERAL REQUIREMENTS

E-0.1 Before the completed installation, or an addition to the existing installation, is put into service, inspection and testing shall be carried out in accordance with the Indian Electricity Rules, 1956. In the event of defects being found, these shall be rectified, as soon as practicable and the installation retested.

E-0.2 Periodic inspection and testing shall be carried out in order to maintain the installation in a sound condition after putting into service.

E-0.3 Where an addition is to be made to the fixed wiring of an existing installation, the latter shall be examined for compliance with the recommendations of this code.

E-0.4 The individual equipment and materials which form part of the installation shall generally conform to the relevant Indian Standard Specification wherever applicable. If there is no relevant Indian Standard Specification for any item, these shall be approved by the appropriate authority.

E-1. INSPECTION OF THE INSTALLATION

E-1.0 General — On completion of wiring a general inspection shall be carried out by competent personnel in order to verify that the provisions of this code and that of Indian Electricity Rules, 1956 have been complied with. This, among other things, shall include checking whether all equipments, fittings, accessories, wires/cables, used in the installation are of adequate rating and quality to meet the requirement of the load. General workmanship of the electrical wiring with regard to the layout and finish shall be examined for neatness that would facilitate easy identification of circuits of the system, adequacy of clearances, soundness of termination with respect to tightness, contact pressure and contact area. A complete check shall also be made of all the protective devices, with respect to their ratings, range of settings and co-ordination between the various protective devices.

E-1.1 Items to be Inspected

E-1.1.1 *Substation Installations* — In substation installations, it shall be checked whether:

1) The installation has been carried out in accordance with the approved drawings;
2) Phase to phase and phase to earth clearances are provided as required;
3) All equipments are efficiently earthed and properly connected to the required number of earth electrodes;
4) The required ground clearance to live-terminals is provided;
5) Suitable fencing is provided with gate with locking arrangements;
6) The required number of caution boards, fire-fighting equipments, operating rods, rubber mats, etc, are kept in the substation;

7) In case of indoor substation, sufficient ventilation and draining arrangements are made;
8) All cable trenches are provided with non-inflammable covers;
9) Free accessibility is provided for all equipments for normal operation;
10) All name plates are fixed and the equipments are fully painted;
11) All construction materials and temporary connections are removed;
12) Oil-levels, busbar tightness, transformer top position, etc, are in order;
13) Earth pipe troughs and cover slabs are provided for earth electrodes/earth pits and the neutral and LA earth pits are marked for easy identification;
14) Earth electrodes are of GI pipes or CI pipes or copper plates. For earth connections, brass bolts and nuts with lead washers are provided in the pipes/plates;
15) Earth pipe troughs and oil sumps/pits are free from rubbish and dirt and gravel and the earth connections are visible and easily accessible;
16) HT and LT panels and switchgears are all vermin- and damp-proof and all unused openings or holes are blocked properly;
17) The earth busbars have tight connections and corrosion-free joint surfaces;
18) Control switch-fuses are provided at an accessible height from ground;
19) Adequate headroom is available in the transformer room for easy topping-up of oil, maintenance etc;
20) Safety devices, horizontal and vertical barriers, busbar covers/shrouds, automatic safety shutters/doors interlock, handle interlock are safe and in reliable operation in all panels and cubicles;
21) Clearances in the front, rear and sides of the main HV and LT and sub-switchboards are adequate;
22) The gap in the horngap fuse and the size of fuse are adequate;
23) The switches operate freely; the 3 blades make contact at the same time, the arcing horns contact in advance; and the handles are provided with locking arrangements;
24) Insulators are free from cracks, and are clean;
25) In transformers, there is any oil leak;
26) Connections to bushings in transformers for tightness and good contact;
27) Bushings are free from cracks and are clean;
28) Accessories of transformers like breathers, vent pipe, buchholz relay, etc, are in order;
29) Connections to gas relay in transformers are in order;
30) Oil and winding temperature are set for specific requirements in transformers;
31) In case of cable cellars, adequate arrangements to pump out water that has entered due to seepage or other reason; and
32) All incoming and outgoing circuits of HT and LT panels are clearly and indelibly labelled for identifications.

E-1.1.2 *Medium Voltage Installation* — In medium voltage installations, it shall be checked whether:

1) All blocking materials that are used for safe transportation in switchgears, contactors, relays, etc, are removed;
2) All connections to the earthing system are feasible for periodical inspection;
3) Sharp cable bends are avoided and cables are taken in a smooth manner in the trenches or alongside the walls and ceilings using suitable support clamps at regular intervals;
4) Suitable linked switch or circuit-breaker or lockable push button is provided near the motors/apparatus for controlling supply to the motor/apparatus in an easily accessible location;
5) Two separate and distinct earth connections are provided for the motor/apparatus;
6) Control switch-fuse is provided at an accessible height from ground for controlling supply to overhead travelling crane, hoists, overhead busbar trunking;
7) The metal rails on which the crane travels are electrically continuous and earthed and bonding of rails and earthing at both ends are done;
8) Four core cables are used for overhead travelling crane and portable equipment, the fourth core being used for earthing, and separate supply for lighting circuit is taken;
9) If flexible metallic hose is used for wiring to motors and other equipment, the wiring is enclosed to the full lengths, and the hose secured properly by approved means;
10) The cables are not taken through areas where they are likely to be damaged or chemically affected;
11) The screens and armours of the cables are earthed properly;
12) The belts of the belt driven equipments are properly guarded;

13) Adequate precautions are taken to ensure that no live parts are so exposed as to cause danger;

14) Ammeters and voltmeters are tested; and

15) The relays are inspected visually by moving covers for deposits of dust or other foreign matter.

E-1.1.3 *Overhead Lines* — For overhead lines it shall be checked whether:

1) All conductors and apparatus including live parts thereof are inaccessible;

2) The types and size of supports are suitable for the overhead lines/conductors used and are in accordance with approved drawing and standards;

3) Clearances from ground level to the lowest conductor of overhead lines, sag conditions, etc, are in accordance with the relevant standard;

4) Where overhead lines cross the roads or cross each other or are in proximity with one another, suitable guarding is provided at road crossings and also to protect against possibility of the lines coming in contact with one another;

5) Every guard wire is properly earthed;

6) The type, size and suitability of the guarding arrangement provided is adequate;

7) Stays are provided suitably on the overhead lines as required and are efficiently earthed or provided with suitable stay insulators of suitable voltages;

8) Anti-climbing devices and Danger Board/Caution Board/Notices are provided on all HT supports;

9) Clearances along the route are checked and all obstructions such as trees/branches and shrubs are cleared on the route to the required distance on either side;

10) Clearance between the live conductor and the earthed metal parts are adequate; and

11) For the service connections tapped-off from the overhead lines, cut-outs of adequate capacity are provided.

E-1.1.4 *Lighting Circuits* — The lighting circuits shall be checked whether:

1) Wooden boxes and panels are avoided in factories for mounting the lighting boards and switch controls, etc;

2) Neutral links are provided in double pole switch-fuses which are used for lighting control, and no fuse is provided in the neutral;

3) The plug points in the lighting circuit are all of 3-pin type, the third pin being suitably earthed;

4) Tamper-proof interlocked switch socket and plug are used for locations easily accessible;

5) Lighting wiring in factory area is taken enclosed in conduit and conduit properly earthed, or alternatively, armoured cable wiring is used;

6) A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipments;

7) Proper connectors and junction boxes are used wherever joints are to be made in conductors or cross over of conductors takes place;

8) Cartridge fuse units are fitted with cartridge fuses only;

9) Clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary;

10) The polarity having been checked and all fuses and single pole switches are connected on the phase conductor only and wiring is correctly connected to socket-outlets;

11) Spare knockouts provided in distribution boards and switchfuses are blocked;

12) The ends of conduits enclosing the wiring leads are provided with ebonite or other suitable bushes;

13) The fittings and fixtures used for outdoor use are all of weatherproof construction, and similarly, fixtures, fittings and switchgears used in the hazardous area are of flame-proof application;

14) Proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals;

15) Flat ended screws are used for fixing conductor to the accessories; and

16) Use of flat washers backed up by spring washers for making end connections is desirable.

E-2. TESTING OF INSTALLATION

E-2.0 General — After inspection, the following tests shall be carried out, before an installation or an addition to the existing installation is put into service. Any testing of the electrical installation in an already existing installation shall commence after obtaining permit to work from the engineer-in-charge and after ensuring the safety provisions.

E-2.1 Testing

E-2.1.1 *Switchboards*—HT and LT switchboards shall be tested in the manner indicated below:

1) All high voltage switchboards shall betested for dielectric test in the manner recommended in IS : 8623 (Part 1)-1977*.
2) All earth connections shall be checked for continuity.
3) The operation of all protective devices shall be tested by means of secondary or primary injection tests.
4) The operation of the breakers shall be tested from all control stations.
5) Indication/signalling lamps shall be checked for proper working.
6) The operation of the breakers shall be tested for all interlocks.
7) The closing and opening timings of the breakers shall be tested wherever required for auto-transfer schemes.
8) Contact resistance of main and isolator contacts shall be measured.
9) The specific gravity of electrolyte and the voltage of the control battery shall be measured.

E-2.1.2 *Transformers* — Transformers are tested in the manner indicated below:

1) All commissioning tests as listed in IS : 10028 (Part 2)-1981† shall be carried out.
2) Insulation resistance on HT and LT windings shall be measured at the end of one minute as also at the end of 10 minutes of measuring the polarization index. The absolute value of insulation resistance should not be the sole criterion for determining the state of dryness of the insulation. Polarization index values should form the basis for determining the state of dryness of insulation. For any class of insulation the polarization index should be greater than 1·5.

E-2.1.3 *Cables* — Cable installations shall be checked as follows:

1) It shall be ensured that the cables conform to the relevant Indian Standards. Tests shall also be done as laid down in IS : 1255-1983‡. The insulation resistance before and after the tests shall be checked.
2) The insulation resistance between each conductor and against earth shall be measured The insulation resistance varies with the type of insulation used and with the length of cable. The following empirical rule gives reasonable guidance:

$$\text{Insulation resistance in megohms} = \frac{10 \times \text{voltage in kV}}{\text{length in km}}$$

E-2.1.4 *Motors and Other Equipments* — The following tests are made on motor and other equipment:

1) The insulation resistance of each phase winding against the frame and between the windings shall be measured. Megohmmeter of 500 V or 1 000 V rating shall be used. Star points should be disconnected. Minimum acceptable value of the insulation resistance varies with the rated power and the rated voltage of the motor.

   The following relation may serve as a reasonable guide:

$$Ri = \frac{20 \times E_n}{1\,000 + 2P}$$

   where

   Ri = insulation resistance in megohms at 25°C,

   E_n = rated phase to phase voltage, and

   P = rated power in kW.

If the resistance is measured at a temperature different from 25°C, the value shall be corrected to 25°C.

The insulation resistance as measured at ambient temperature does not always give a reliable value, since moisture might have been absorbed during shipment and storage. When the temperature of such a motor is raised, the insulation resistance will initially drop considerably, even below the acceptable minimum. If any suspicion exists on this score, motor winding must be dried out.

E-2.1.5 *Wiring Installation* — The following tests shall be done:

a) The insulation resistance shall be measured by applying between earth and the whole system of conductor or any section thereof with all fuses in place and all switches closed, and except in earthed concentric wiring, all lamps in position or both poles of installation otherwise electrically connected together, a dc voltage of not less than twice the working voltage, provided that it does not exceed 500 volts for medium voltage circuits. Where the supply is derived from three-wire (ac or dc) or a poly-phase system, the neutral pole of which is connected to earth either direct or through added resistance the working voltage shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.

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*Specification for factory-built assemblies of switchgear and controlgear for voltages up to and including 1 000 V ac and 1 200 V dc: Part 1 General requirements.

†Code of practice for selection, installation and maintenance of transformers: Part 2 Installation.

‡Code of practice for installation and maintenance of power cables up to and including 33 kV (*second revision*).

b) The insulation resistance in megohms of an installation measured as in (a) shall not be less than 50 divided by the number of points on the circuit, provided that the whole installation need not be required to have an insulation resistance greater than one megohm.
c) Control rheostats, heating and power appliances and electric signs, may, if desired, be disconnected from the circuit during the test, but in that event the insulation resistance between the case or framework, and all live parts of each rheostat, appliance and sign shall be not less than that specified in the relevant Indian Standard Specification or where there is no such specification shall be not less than half a megohm.
d) The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire or to the neutral on to the other pole of phase conductors of the supply. Such a test shall be made after removing all metallic connections between the two poles of the installation and in these circumstances the insulation resistance between conductors of the installation shall be not less than that specified in (b).

On completion of an electrical installation (or an extension to an installation) a certificate shall be furnished by the contractor, countersigned by the certified supervisor under whose direct supervision the installation was carried out. This certificate shall be in a prescribed form as required by the local electric supply authority.

E-2.1.6 *Earthing* — For checking the efficiency of earthing the following tests are done:

a) The earth resistance of each electrode shall be measured.
b) The earth resistance of earthing grid shall be measured.
c) All electrodes shall be connected to the grid and the earth resistance of the entire earthing system shall be measured.

These tests shall preferably be done during the summer months.

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